The

ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XVII No. 5. MAY, 1956

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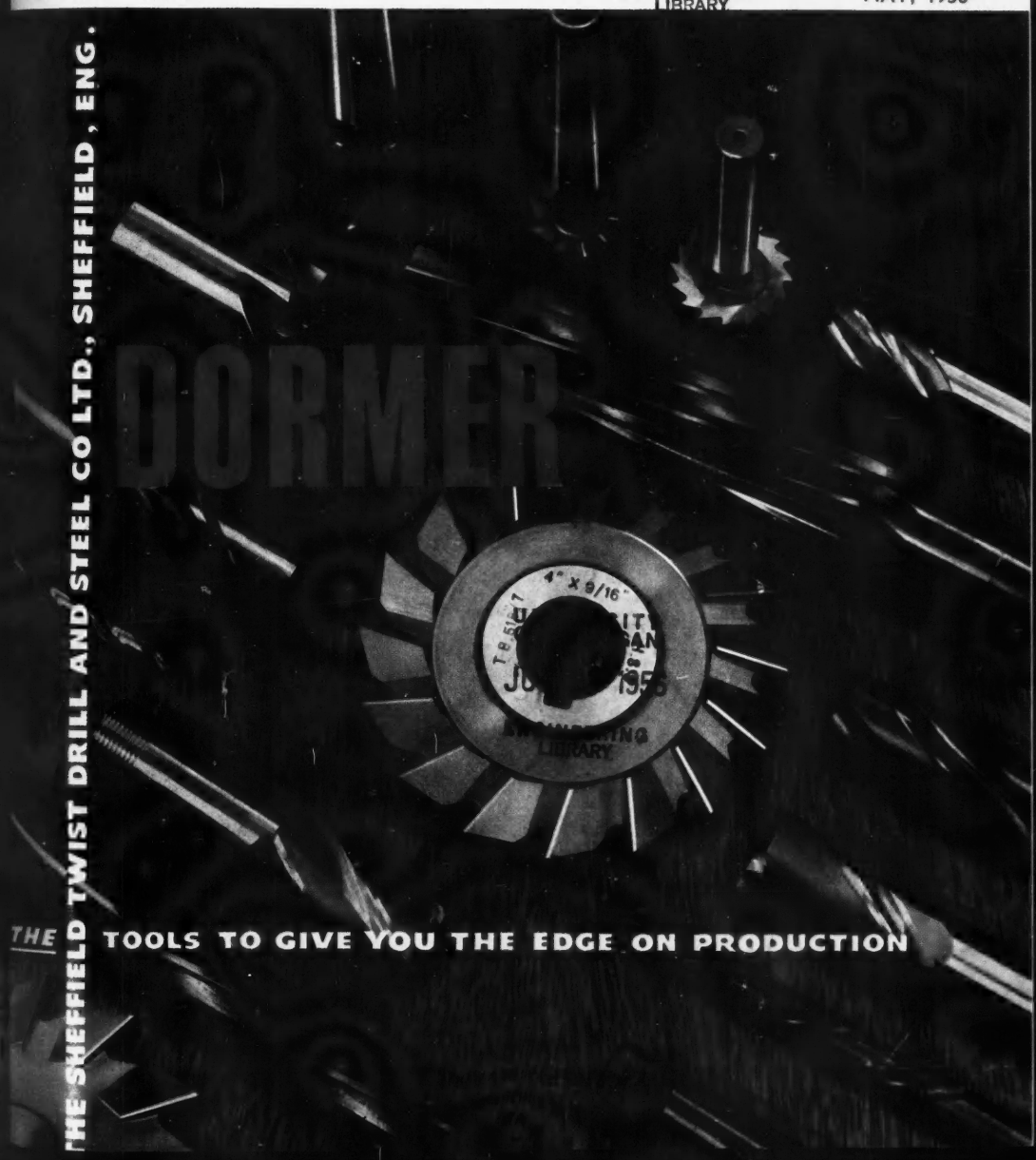

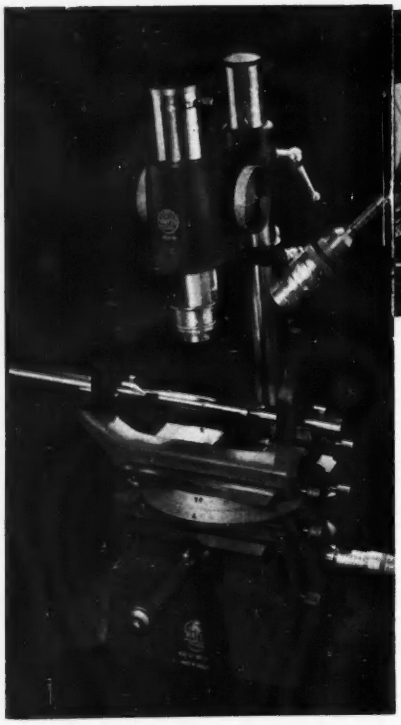

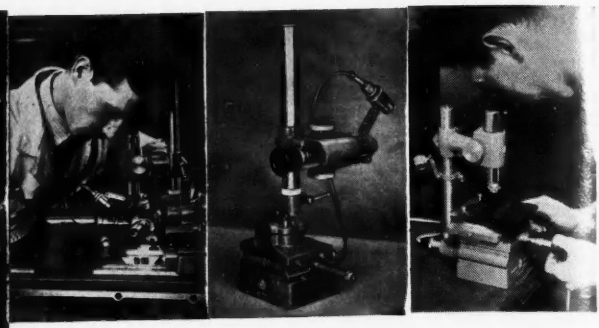

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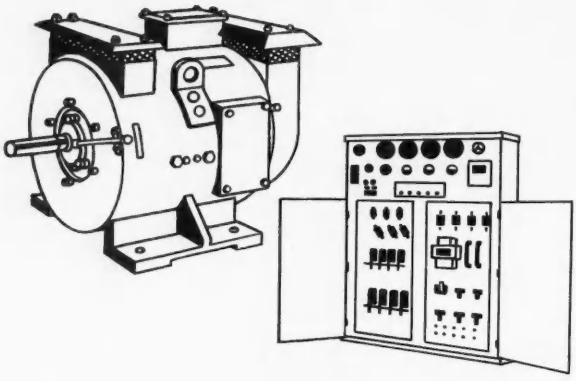

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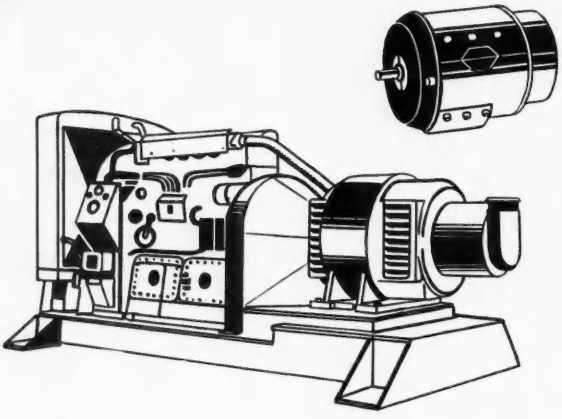

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● ***HYDRAULIC FLAW-DETECTION DEVICE***

A hydraulic testing machine has been devised which tests for porosity and other flaws in small cored-out passages of large cast-iron housings, and automatically accepts or rejects the parts, as determined by the rate of advance of a piston loosely fitting in a long narrow cylinder. When the workpiece is ready for test, external probes move in automatically and seal off the extremities of the passages to be tested, none of the passages being threaded. In the purging operation prior to the actual test, all traces of air are eliminated from the system. When the purging operation is completed, a valve, operated by a hydraulic motor, seals off the localized test passages from the main supply and discharge lines, isolating the testpiece and seal-locking it from the system. At the same time, this valve admits oil to a larger actuating cylinder, forcing the loosely fitting piston into a long narrow cylinder, which builds up the test pressure in the isolated system. If there are no leaks, the piston does not advance but, if there are leaks, the piston advances in proportion to the severity of the leakage, and in the case of a severe failure the piston will trip a limit-switch which cuts off the power. A major feature of the machine is the design and operation of the force-differential seal locks. These not only supply oil to the passages, but gradually increase in contact pressure as the pressure builds up, so that effective sealing at the test pressure is safeguarded.

● ***DAYLIGHT RADAR SCREEN***

The dimness of the picture shown on radar screens has long been a problem. It is now reported that a probable solution has been found in the form of a direct-view storage tube. The chief components of the equipment are a writing gun, a storage target, a flood gun used for reading, and a phosphor screen. The writing gun is similar to that used in a standard radar cathode-ray tube, except that it is smaller and more sensitive. The storage target is the heart of the device and consists of a fine metal mesh screen upon which is deposited an insulating material. The assembly can store an electrostatic charge in the spot pattern written upon it by the writing gun, while the flood gun supplies a large continuous beam of electrons focused to spread out over the entire storage surface. The flood is controlled by the charge pattern stored on the target. At any given spot the quantity of electrons accelerated to pass through the mesh depends upon the amount of positive or negative charge at each point. The electron pattern passing through the mesh therefore represents an exact image of charge stored on the target. The electron image in the flood beam is then accelerated by the high voltage on the phosphor-screen and a luminescent output is produced by each point on the screen. Because the beam impinges continuously on the phosphor screen, compared with once every few seconds in a radar tube, the picture display is correspondingly brighter.

● ***TRANSITION TEMPERATURE FOR SURFACE DAMAGE IN SLIDING CONTACT***

It has been known for some time past that in inert atmospheres two distinct kinds of repetitive sliding occur for metallic couples. These were classified as (a) sliding by shear and (b) sliding by welding. Sliding by shear has been observed to occur for non-alloying couples and is typified by a relatively low coefficient of friction, a smooth and relatively small contact area on the slider, and a smooth wear-track on the mating metal surface. Sliding by welding occurs in the case of alloying couples and is identified by a high coefficient of friction, a large and abraded contact area on the slider, and similar damage to the wear-track. In a recent paper the author considers the effect of liquid atmospheres and temperature on the repetitive sliding of alloying couples, especially copper-copper, copper-nickel, and nickel-nickel, and has found that there exists a transition temperature for the various liquids tested, below which sliding by shear takes place, and above which sliding by welding occurs. The transition is said to take place abruptly with temperature, and is repetitive as the temperature is raised or lowered through the critical range. Thus, the "damage" introduced by sliding for prolonged periods above the critical temperature can be "repaired" by continuing the sliding at temperatures below the critical value. The author also reports on the significance of such variables as speed of sliding, normal load, kind of fluid, and kind of metal upon the critical temperature, and a mechanism for the phenomenon is proposed on the basis of surface-diffusion effects.

Meet Perishin' Fred!

Very fond of a grouse is Fred. Doesn't have to look far either. 'Like the perishin' North Pole in this perishin' factory', growls Fred. But at least he stays on the job; half the girls are away with the sniffles.

Now meet Bert — of the boiler'ouse

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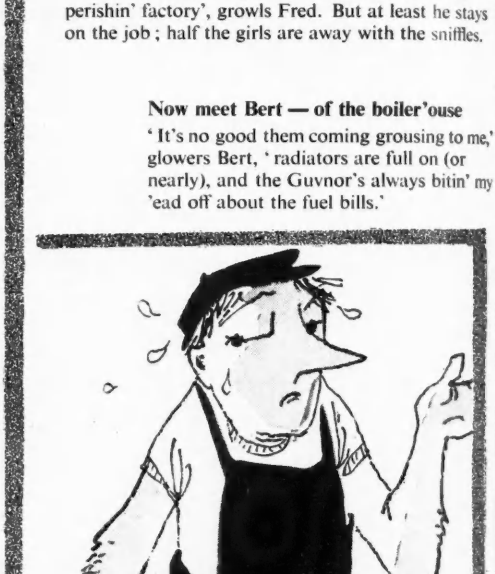

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• *NEW METAL-BONDED ELECTRICAL CONTACT MATERIAL*

A recent patent covers a method of producing metal-bonded boride parts for the purpose of providing an improved material for the facing of electrical contacts. Since borides are highly refractory and offer a good measure of oxidation resistance, they confer on the contact material a considerable resistance to electrical and mechanical wear. Buttons formed from the new composite material may be affixed by brazing to the copper contacts of electrical circuit-breakers and contactors to replace materials at present in use. It is also claimed that the material is generally useful where hardness and resistance to oxidation and welding are required, thus making it especially suitable for the tips of resistance-welding electrodes. It is stated that, when tipped with the composite material, a resistance-welding electrode can be used continuously for welding materials with high melting points with little danger of the electrode welding itself to the workpiece material. The method of producing the composite material can be applied to different borides, and zirconium, vanadium, chromium, and tungsten borides are mentioned. The bonding metal may consist of cobalt, nickel, iron, or chromium. Pieces of the material are produced by packing the boride powder loosely into a mould of refractory material such as graphite, and placing the requisite amount of bonding metal of lower melting point than the boride upon the surface of the boride powder. Upon heating, the melting metal will then infiltrate into the voids in the boride mass. Heating should be carried out under oxidizing conditions. An alternative process consists of first compacting the boride powder and sintering it; this is then followed by infiltrating the metal of lower melting point. In the case of electrical contact material produced by this method, it is stated that the percentage volume of the bonding metal may be as high as 25 to 35%.

• *NEW POLYAMIDE RESINS BASED ON VEGETABLE OILS*

It is reported that a new series of thermoplastic polyamides has been developed, ranging from hard, tough, solid materials to liquid compounds suitable as adhesives and coatings. These new plastics are based on vegetable oils which are reacted to produce plastic monomers. In the solid state these plastics are amber-coloured, have molecular weights ranging from 3000 to 10,000, and softening points ranging from 115 to 375°F. In general, these plastics are non-inflammable, non-toxic, and resistant to water, alkalis, most acids, oils, and many organic solvents. Their dielectric properties are said to be excellent, while some of them are compatible with certain waxes, and all are compatible with most phenolics. Perhaps the greatest attraction is that several modifications are compatible with epoxy resins and react with them to produce a new group of compounds. By blending with liquid epoxies, adhesives and laminating varnishes are obtained which, after polymerization, become thermosetting materials. In these compounds the polyamide component imparts initial tack and after cure becomes an internal plasticizer. The cured materials are reported to have greater resistance to impact and thermal shock than amine-cured epoxies. Also, they show good resistance to most chemicals and have a high degree of adhesion to a wide variety of materials. They can be prepared without the use of solvents and cure at moderate temperatures. With one typical blend of the adhesive variety, bonds on aluminium have shown a shear strength of 2700 to 3500 psi.

• *PROCESS FOR IMPROVING THE BONDING QUALITIES OF TEFLON*

It is reported that teflon, in section thicknesses down to 0·005 in. can now be bonded to practically any cementable material with the use of conventional adhesives. The tensile shear-strength bonds are claimed to be of the order of 114 to 354 psi, depending on the kind of adhesive used and the material to which the teflon is bonded. This advance has been secured by the development of a new treatment which chemically etches the teflon surfaces, so that adhesives can form a mechanical bond. The treatment is essentially simple and consists of the immersion of teflon in a bath for a specified period, followed by a quench in cold water. The bath consists of metallic sodium dissolved in liquid anhydrous ammonia, and the maximum recommended strength of the solution is about 1%. When sodium is added to liquid ammonia, a characteristic dark-blue solution is obtained. During all operations moisture must be excluded from the processing tank, to prevent a poor bonding surface on the resulting product. As the teflon emerges from the bath after a dipping time of 1 to 5 seconds, the residual ammonia volatilizes upon exposure to air. However, residual sodium hydroxide and treating solution should be removed by a cold-water quench. The material is then removed from the cold-water bath and dried, after which it has a dull dark-brown colour. The treated teflon is expected to find use wherever the characteristics of teflon, such as anti-stick properties, chemical resistance, and toughness, are required on the surface of another material. Such applications will be found in many fields, and include facings for valves and machine parts, insulation for electric motors and electronic coils, frictionless facings for conveyor guide-rails, and liners and coverings for tanks, pipes, and ducts.

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● *FIELD-EMISSION TYPE OF ELECTRONIC VALVES*

The rapid advances in transistor technique have stimulated the search for other devices to supplement or even to supplant the thermionic valve. Of particular significance in this respect is a recent announcement that a new electronic device, termed a megawatt field-emission cathode, has been developed, which may permit important advances in the fields of communications, X-ray, and other electronic valve applications. The megawatt cathode employs the principle of field emission, which constitutes an electron source not previously employed for practical purposes. It is considered that this new development may be as important to high-power valves as the transistor is proving to lower-power devices. While in thermionic valves electrons are produced by the cumbersome and expensive process of heating a metal filament in a vacuum tube, in the field-emission process no external heating is required except for stabilization. A field emitter consists of a very small tungsten needle, less than 10^{-4} in. in diameter and, in spite of the small size of the needle, its electron supply is so sensitive to the applied voltage that currents of several amperes can be drawn from one such needle. When several emitters of this type are placed in parallel in a comb-like arrangement, currents up to 20 A at a peak power of more than 1000 kW are obtainable. Current densities of 10^8 A/cm^2 have been realized from field emitters having diameters of 10^{-4} to 10^{-5} cm. It is expected that further research may result in even greater power. In the experiments carried out so far, the electron source was successfully operated in practical form by using an intermediate temperature to maintain a smooth, clean metal surface and by limiting the emission to pulses such as those used in radar. In its present state of development the electron source appears particularly useful in pulsed electronic devices.

● *SPRINGS OF REINFORCED PLASTIC*

It is claimed that helical springs made of glass-reinforced polyester and epoxy resins have been produced and tested with remarkable success. There is no doubt that for most purposes springs made of steel or other resilient metallic materials will retain their superiority in the vast majority of cases; nevertheless, springs of polymeric materials may prove highly useful for certain applications. Typical characteristics of springs made of plastic are derived from the fact that the material has low thermal and electrical conductivity, has good strength-to-weight characteristics, and can be obtained in a transparent, translucent, or opaque form. In addition to these inherent characteristics, plastics can be moulded directly to final dimensions without developing considerable internal stresses, as contrasted with metal helical springs, which after being formed generally uncoil slightly, increasing in diameter and sometimes in length. On the other hand, plastics are more sensitive to time and temperature than metals. Much research has been carried out in order to find the plastic materials most suitable for spring manufacture. In general, polyesters were found to be more sensitive to elevated temperatures than epoxies, although different epoxy materials vary widely in this respect. It is claimed that, on the basis of torsional moduli and temperature sensitivity, polyester and epoxy resins would appear to be the most promising for spring applications. The springs used for these tests were moulded by drawing resin-soaked glass-fibre rovings through vinyl copolymer tubing, wrapping it helically around mandrels, and removing it after curing.

● *AEROSOL PARTICLE COUNTER*

Present-day methods used for aerosol particle counting consist of collecting the minute particles on a surface and then counting and sizing them under a microscope. An electronically operated particle counter has now been developed which in one operation automatically detects particles in a gas and classifies them into 12 consecutive size groups, ranging from 1 to 64 microns in diameter. The apparatus counts and classifies at a maximum rate of 100 particles per second and can deal with aerosols having particle concentrations up to 10,000 particles per cm^3, detection being based on the light-scattering effect of the particles. For this purpose a thin aerosol stream is made to intersect a high-intensity light beam, and a portion of the light energy scattered by the particles is received by a multiplier phototube. The gas volume illuminated and viewed by the detector measures 3 by 3 mm horizontal by 1 mm vertical. At the maximum counting rate, an average of 95% of the aerosol particles is passed through the sensitive volume, one at a time; thus, for each particle traversing the illuminated field, a nearly square pulse of light is transmitted to the multiplier phototube. The aerosol velocity is given as approximately 5 fps. This value, in conjunction with the 1-mm vertical dimension of the sensitive volume, yields a signal-pulse duration of 650 microsec. The intensity of the light impulse varies with the square of the particle diameter for particles within the 1 to 64 micron range, and the dynamic range of signal voltages is therefore 64^2 or 4096 to 1. The random voltage pulses from the phototube are amplified in a pre-amplifier and fed to a pulse-height discriminator, where they are classified into the 12 consecutive size groups and tallied on a counter within each group.

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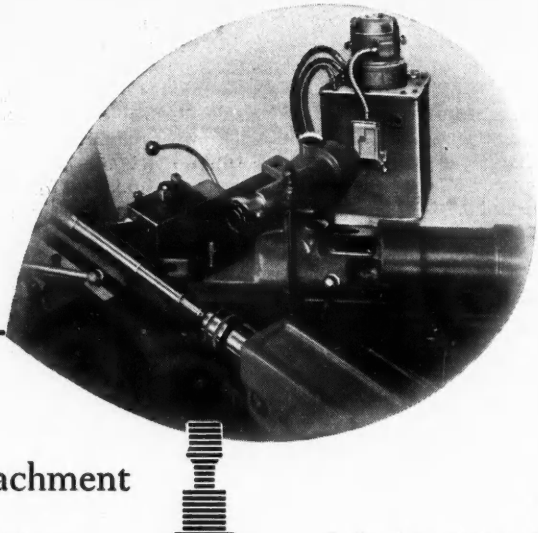

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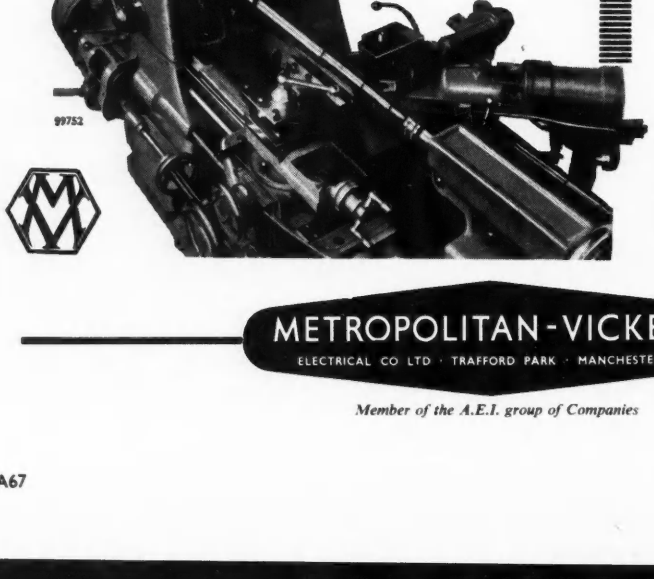

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● *NEW METHOD OF FINISHING FORGING DIES*

The die forging of parts with an accuracy that makes subsequent machining unnecessary, as required, for instance, for the teeth of bevel gears, calls for dies made to very close tolerances. The making of such dies is known to be a time-consuming and therefore costly process and requires a very high degree of skill. There are no special machines available for this purpose, and in the case of dies for making bevel gears it is necessary to finish by hand the negative teeth after they have been rough-machined, giving rise to faults and inaccuracy in the tooth profile and in the pitch of the gear. In a recent patent a novel method of die finishing appears to hold considerable promise. In this method the inner surface of the die is first rough-machined to a greater or lesser degree of accuracy, after which it is coated with an acid-resistant lacquer which hardens after application. A positive pattern corresponding exactly to the part to be produced is then pressed into the die with such a pressure that the lacquer coating is destroyed in the areas against which the pattern bears, so that the metal surface is exposed. The positive pattern is then removed from the die and an etchant applied, removing any excess metal on the exposed metal surfaces. After cleaning the die, the process is repeated until the entire surface of the die bears evenly, i.e., the positive pattern bears uniformly against the inner surface of the die at all points. It is claimed that this method can be carried out by unskilled labour.

●*HIGH-SPEED GEAR-SHAVING PROCESS*

A novel, high-speed planetary shaving process is claimed to produce uniform, accurate, thin-tooth sections in the flanks of spur-gear teeth. The process was developed to meet the needs of gear-transmission builders. When a thin-tooth section is provided in a transmission clutch gear, all tendencies of the transmission to slip out of gear are avoided. The machine built to carry out the process is said to be capable of producing a variety of thin-tooth section edge shapes to suit the requirement for shifting of particular transmissions. The section can be produced in either or both sides of the teeth. The profile of the section closely approximates to an involute form and usually is well within required involute profile tolerances. The planetary shaver has a hardened and ground high-speed steel cutter which resembles an internal spline. The workpiece, i.e., the gear to be shaved, is mounted in a three-jaw tooth chuck in mesh with the cutter, and rotates around the cutter centre-line during the shaving process. Since the cutter has single cutting edges, which alternately thin first one side of the teeth and then the other, a time relationship is maintained between the gear and the cutter. This is achieved by locating the gear radially in the toothed chuck jaws and rotating the chuck with a master gear and internal gear assembly located at the back of the cutter. At the loading position, the gear is located so that it is in backlash position with respect to each of the cutting edges of the planetary shaving cutter. When the automatic cutting cycle is initiated, the gear axis is rotated and the cutter is fed tangentially in increments, first in one direction, next back to backlash position, then in the opposite direction, and finally back to the backlash position for unloading.

● *HEAT PHOTOGRAPHY*

An apparatus has been developed which, because of its extreme sensitivity to infra-red radiation, can produce a direct "thermal" photographic picture. The instrument is similar to a camera and incorporates a thin membrane, 4 microinches in thickness, set in an evacuated cell between an optical system and a viewer. The cell is so designed that oil can be condensed uniformly on one side of the membrane. The optical system picks up the infra-red radiation from the field of view and forms an image on the membrane. The membrane is provided with a coating which absorbs the radiation and changes the temperature of the membrane from point to point, according to the amount of radiation received. This change in temperature alters the thickness of the oil film on the other side of the membrane and, when seen in reflected white light, these differences in oil-film thickness appear as different colours, like oil films on water. The normal membrane is yellow when seen through a viewer, but as oil condenses on the membrane it builds up in thickness, and the colour changes to red, then blue, and back to yellow. The density of a series of membrane photographs taken during this cycle also varies, cycling in the same manner. Therefore, the radiation from the field of view can be measured visually and photographically, by comparing the rate of thickness change in terms of colour or density with the rate of radiation from a body of known temperature and emissivity. These results can be converted to temperatures. It is claimed that the instrument can "see" radiation differences corresponding to temperatures up to several thousand degrees Fahrenheit. In addition to being able to take actual photographs in the dark, e.g., a picture of a house in winter, so as to locate points where heat is escaping, the instrument can be used for temperature checking and measurement in a number of applications, such as testing electronic components or the surface of pressure vessels in service. Similarly, it has been used to check the hot spots on an engine.

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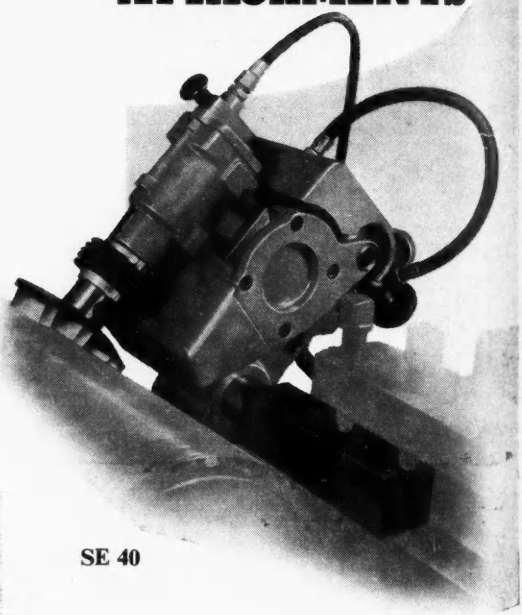
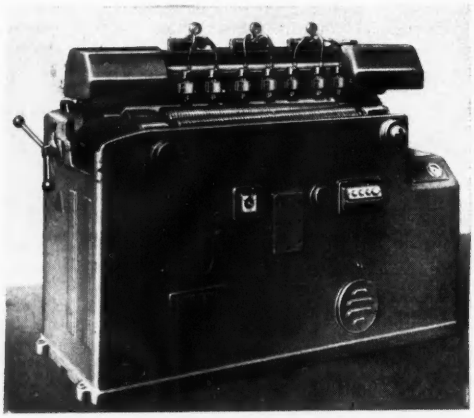


SE 40



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THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
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Ceramics as Basic Engineering Materials

By E. J. SMOKE and J. H. KOENIG. (From *Mechanical Engineering, U.S.A.*, Vol. 78, No. 4, April 1956, pp. 315–318, 6 illustrations.)

AMONG the unique properties of ceramic materials is refractoriness, i.e., resistance to high temperatures. The melting temperatures of the basic crystalline phases of most ceramic materials are quite high, starting in the range of 3000°F. Glasses are also ceramic materials, but they cannot be considered as refractories, because they are not compounds but rather behave as supercooled liquids whose viscosity is extremely high at room temperature ; thus, they have softening ranges rather than melting temperatures.

MELTING TEMPERATURES

Ceramic products are being manufactured with melting temperatures lower than 3000°F, principally due to a high glass content. Ceramics made of clinoenstatite, titania, silica, mullite, forsterite, alumina, spinel, zircon, beryllia, zirconia, magnesia, and thoria are oxide-type ceramics. All but the first two are used as refractory materials where high-temperature processing is involved. Thoria has a very high melting point ; however, it is radioactive. Silicon carbide is used as a refractory and to a large extent as kiln furniture. Boron carbide has a high melting temperature but it is used only in special cases. Other carbides, sulphides, nitrides, and borides have still higher melting temperatures but have only been made experimentally or on a very limited scale because of the rarity of some of the elements involved and the protective atmosphere necessary in using these materials. They are being used experimentally in heat-engine parts such as jets and rockets.

The metal with the highest melting point is tungsten, which melts at approximately 6100°F. Zirconium, tantalum, and hafnium carbides, and graphite have higher melting temperatures, with hafnium carbide having the highest melting temperature known (about 7520°F).

Ceramic products are generally a mixture of one or more crystalline phases with glass, the latter material varying up to approximately 45%. This glass content affects the refractory properties. The best glasses can be used continuously only up to approximately 900°F. Steatite and forsterite can be used continuously to 1830°F without distortion, when used as technical ware, such as high-frequency insulation, or whenever dimensional tolerances in the range of $\pm 1\%$ are prerequisite. However, forsterite, when used for furnace parts, operates successfully up to 3000°F. Normal porcelains have been used up to 2185°F. Zircon, whether used as a technical ceramic or as a refractory, operates very well up to 2650°F. Silicon carbide, which is used in furnace parts, stands up very well to approximately 2750°F in air. Silica is used principally as a refractory in open-hearth furnaces, where the temperature approaches 3000°F. Mullite refractories are used continuously up to 3200°F.

The effect of glass content and/or an additional crystalline phase or phases is illustrated by the safe continuous operating temperatures of several alumina bodies. A body containing 86% alumina can be used continuously up to 2550°F ; another containing 96% can be used up to 3050°F, while pure recrystallized alumina, containing no glass, can be used continuously up to 3520°F. These are used as furnace parts and technical ceramics of close dimensional tolerance and for high-temperature vacuum applications.

Zirconia provides a very high safe continuous operating temperature (about 4200°F), and in the fused stabilized form is used for furnace parts.

Alumina and zirconia are applied to metals in thicknesses up to 0·010 in. by the flame-spray process. This type of coating shows promise for heat-engine parts, abrasion-resistant coatings, and erosion-resistant parts.

HARDNESS

Hardness is another property unique to ceramics, covering the range from 30 on the Knoop scale for the mineral gypsum to 7000 + for diamond. Glasses range from 300 to 500. The hardest metals are hardened steel at Rockwell C 60·5, which is approximately 750 on the Knoop scale. Several ceramic materials also fall into this range but the majority possess greater hardness. The cemented carbides are made of synthetic ceramic materials such as tungsten, titanium, and tantalum carbides, whose Knoop-hardness numbers range from 1400 to 1800.

Alumina has a Knoop hardness of 2000 and is used as a grinding and lapping compound, and as the abrading media in grinding wheels for machining steel. A relatively new application is in tool bits for machining metals. This extreme hardness and the fact that this type of ceramic can be fabricated to extremely close dimensional tolerances lends itself to wear-resistant parts such as gauges, bearings, thread guides, nozzles, and technical ware in general.

Silicon carbide, with a Knoop hardness of 2500, is one of the most important abrasives in terms of lapping and grinding. It lends itself best to fabricating very hard dense materials such as ceramics, including cemented carbides, cast and chilled iron, and non-ferrous metals.

Titanium boride has a Knoop hardness of 2720 and boron carbide 2800. Diamond is the hardest known material. Its extreme hardness and durability make it of economic significance, even though the initial cost is quite high.

The property of extreme hardness has made ceramic abrasives actually indispensable in the fabrication of metals and other materials. There are no substitutes for ceramic abrasives.

THERMAL CONDUCTIVITY

Another engineering property of extreme importance

is thermal conductivity. Again, ceramic products cover a wide range, from near zero up to 125 BTU/hr sq ft/(°F/ft) at 140°F. In the very low range of thermal conductivity a variety of thermal insulating materials is manufactured from mineral products such as asbestos, magnesia, diatomaceous silica, refractory clays, mineral and glass wools, and synthetic fibres; these are used from below room temperature to above 3000°F as drier, oven, and furnace liners and backings, pipe coverings, and in numerous other applications.

Ceramic products in general are characterized by low thermal conductivity, and approximately 98% of all products manufactured have thermal-conductivity values no higher than 5 BTU. This is due not only to the property being inherently low but also to the large percentage of pore space or voids present in some of these materials.

All ceramics possessing thermal-conductivity values above 5 BTU are non-porous materials. Alumina ceramics have thermal-conductivity values up to 10 BTU. Tin oxide has a value of 17 BTU, but has not been used industrially to any extent in ceramic bodies. Lead has a value of 19 BTU. The conductivity of magnesia as a dense ceramic is 27 BTU, and magnesia has been used as electrical insulation in vacuum tubes. Above this range the only ceramic material is beryllia and its value is 125 BTU, as compared with aluminium at 118 and copper at 218. By combining beryllia with other ceramic materials, a range of porcelains can be made whose thermal conductivity ranges from 90 to 30 BTU. Some spark-plug and high-frequency insulators, where high thermal conductivity is of importance, have been made from beryllia and beryllia porcelains. However, because of the toxic effect of this material, its use has been limited, though it is now considered that it can be used safely when the proper precautions are taken.

Thermal Expansion

Ceramic materials are manufactured covering the range of linear thermal expansion from $0{\cdot}5–13 \times 10^{-6}$ in. per in. per °C between room temperature and 700°C. Magnesia has the highest thermal expansion at 12·8. Low-carbon steels have values in the range of 15 over the same temperature range, while copper has a value of approximately 17. One of the prime applications of a desired high thermal expansion in ceramics is in glass-to-metal and ceramic-to-metal seals for electron tubes and other vacuum-tight, strong, high-temperature seals. There are two types of seals : The compression type is exemplified by copper and forsterite or alumina, and Kovar and alumina. In this case a metal of higher thermal expansion surrounds the ceramic of lower thermal expansion, which, when they are soldered together, results in a strong vacuum-tight compression seal. The other type is the matched seal, in which the thermal expansion of metal and ceramic is approximately the same. Glass-to-Kovar is a glass-to-metal seal of this type. The iron-nickel series of alloys covers a wide range of thermal expansion, and a thermal-expansion match can be found for most ceramics, only, however, over a limited temperature range.

Invar is a low-expanding material at relatively low temperatures but tends to expand quite rapidly as the temperature is increased. In the realm of ceramics, much lower thermal expansions are possible. In fact, there are two types which actually contract on heating. Both are lithium aluminosilicates. The one type exhibiting the low positive to low negative values is the crystalline phase beta-spodumene. It can be made to have no contraction or expansion up to 600°C. Beta-eucryptite is the other crystalline phase and its coefficient of linear thermal expansion is $-5{\cdot}6 \times 10^{-6}$. This latter material has not been made in the non-porous state and, because of its very high degree of contraction, has found little use. However, the beta-spodumene is quite important as a refractory material (to 2200°F) of high thermal-shock resistance. Some uses include trays on which dental products are rapidly fired; tubes through which billets are heated to forging temperature by induction heating; and in the firing of certain white wares. It is being used as either non- or low-expanding tubes in dilatometers for determining the thermal expansion of ceramics and metals at higher temperatures. It is being evaluated as a base material for precision electrical resistors and capacitors, where dimensional variation with temperature is detrimental.

Thermal-shock resistance is relatively high in most porous ceramics because of inherent structure. However, where strong ceramics are desired, porosity must be minimized. In dense ceramics the thermal-shock resistance is dependent to a marked degree on thermal expansion ; the lower the thermal expansion the higher the thermal-shock resistance. Similar specimens of an alumina ceramic whose coefficient of linear thermal expansion is 8·0 crack when quenched in water at room temperature from 400°F. Beta-spodumene bodies, whose thermal expansion approaches zero, have resisted failure when water-quenched from 2200°F at room temperature.

Strength

The compressive strength of ceramic materials covers a very wide range, from extremely weak materials to values as high as 600,000 psi in the case of a mixture of 31% (by weight) titanium boride and 69% boron carbide. In general, for more or less conventional ceramics, with tensile strength at unity, the transverse strength is approximately twice, and the compressive strength from 8 to 10 times, the tensile strength. One commercial alumina body has a tensile strength of 27,000 psi, its transverse strength being 50,000 psi, and its compressive strength 290,000 psi. Alumina bodies with compressive strengths as high as 400,000 psi have been reported.

The optimum strength values tend to decrease either with a decrease in the basic crystalline phase or with an increase in pore volume. As an illustration, alumina ceramics are manufactured as special refractories with compressive strengths of the order of 11,000 psi, while, on the other hand, the completely non-porous material used as wear-resistant parts and electrical insulation has a compressive strength of 290,000 psi. This extremely strong material is being used in extrusion- and pressing-die parts, precision gauges, plungers for reciprocating pumps, mechanical-seal parts, bearing sleeves, liners for pumps and impeller-wear parts, thread guides, and as high-frequency insulation, particularly for vacuum-tight ceramic-to-metal seals.

Beryllia is another extremely strong ceramic with a compressive strength of 188,000 psi and a transverse strength of 35,000 psi. Steatite, forsterite, and zircon ceramics have compressive-strength values between 75,000 and 90,000 psi. Steatite is the most economical of the group to manufacture. It is used extensively as electrical insulation, especially for high-frequency applications and at moderately elevated temperatures, because of its high strength, excellent electrical insulating properties, and the ability to fabricate this material to close

dimensional tolerances. Porcelain, glass-bonded mica, and cordierite have lower compressive strengths, in the range of 35,000 to 50,000 psi. Porcelain, because of its strength, ease of manufacture, and general durability, is used extensively for domestic and technical ceramics.

With regard to the effect of temperature on the strength of some ceramic materials, a beryllia ceramic, for example, whose tensile strength is approximately 14,000 psi at room temperature, is still 5000 psi at 1800°F ; its transverse strength at room temperature is 20,000 psi and 11,500 psi at 1800°F, while its compressive strength at the lower temperature is 110,000 psi, 50,000 psi at 1800°F, and 7000 psi at 2912°F. Chromium boride, with a room-temperature transverse strength of 88,000 psi, remains constant at 1700°F. Zirconium boride exhibits the same effect over the same temperature range, with a value of 66,000 psi, and at 2200°F this value drops only to 55,000 psi. The titanium boride-boron carbide material mentioned previously has a transverse strength of 90,000 psi at room temperature and drops steadily to 55,000 psi at 2200°F.

It is these high-strength properties at high temperatures that are of extreme interest for high-temperature engines and air-frames. Radomes which house radar equipment are being made of ceramic materials because of these properties. One laboratory is experimenting with actual missiles made entirely of ceramic materials, the reason being that only ceramic materials can withstand the extreme conditions of temperature and pressure encountered.

BELGIUM

Calculation and Measurement of Critical Speeds of Turbine Rotors

By A. VANDEGHEN, M. ALEXANDRE, and L. LELOUP. (From *Revue Universelle des Mines*, 9th series, Vol. 12, No. 1, January 1956, pp. 3–20, 29 illustrations.)

The basic methods of calculating flexural vibrations of shafts are well known; however, the prediction of critical speeds depends on various assumptions, and it is not always easy to estimate which assumptions will be fulfilled in practice. This is particularly true in the case of turbine rotors.

THE results upon which this article is based have been derived from recent investigations of various types of marine turbines. These turbines consist of either two or three masses coupled through a reduction gear to the propeller, and are required to operate over a range of speeds from slow to maximum service speed. Hence, it is necessary that this maximum speed should be below the first critical speed of the rotor, whereas for constant-speed turbines used in power stations the running speed can frequently be situated between the first and second critical speeds.

In a typical high-pressure turbine, the rotor (Fig. 1) is, in fact, a shaft on two supports, which at first sight would seem fairly easy to calculate. However, it is necessary to know the true points of support of the bearings, the effect of inertia couples and overhung masses, the equivalent length of stepped shaft sections, and the modulus of elasticity at the operating temperature. These factors are investigated, as follows.

Position of Supports:—

In normal running, the reaction forces of the supporting bearing can be assumed to be symmetrically distributed over the length of the bearing (Fig. 2a), the oil film being practically undisturbed by the static deformation of the shaft. When running near the critical speed, the shaft sags more than previously and the oil-film pressure is distributed more or less as shown in Fig. 2b. At the critical speed, the change is even more pronounced, and the inclination of the rotor axis becomes such that only a small portion of the bearing carries the load (Fig. 2c). A this moment, it can be said that the oil film has practically disappeared. Observations on turbines have shown traces of support only over a length of about $\frac{3}{4}$ in. from the inner edge of the bearings. Calculations of critical speeds give appreciably different values, according to whether the points of support are taken at the bearing centres or at their inner edges, e.g., 5650 and 7090 rpm respectively (a ratio of 1·25) for a high-pressure turbine rotor.

For low-pressure turbines the difference is even greater, with ratios of 1·4 or even 1·5, because of the longer bearings and also because the shaft diameters are much smaller, in relation to gland and rotor diameters, than in the case of high-pressure turbines. As an average value, therefore, it is advisable to consider that the supporting points are situated about $\frac{3}{4}$ in. from the inner edge of the bearings.

Effect of Overhung Masses:—

Certain parts of the rotor are on overhung sections of the shaft extending beyond the bearings. Consider, for instance, a rotor with three concentrated masses, two of which are overhung (Fig. 3), when it is running at its critical speed. In contrast with the static case, the deflection curve under dynamic conditions due to centrifugal force shows that the overhung sections act in opposition (in antiphase) to the central portion.

In a typical turbine-rotor system (Fig. 1), on the side of the reduction gear there may be an intermediate shaft

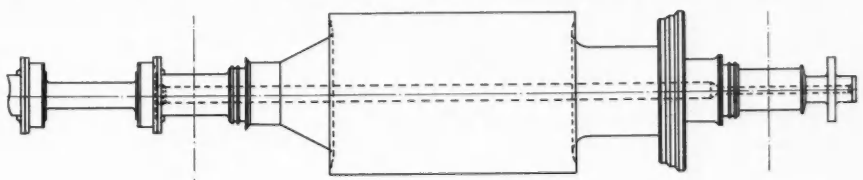


Fig. 1.

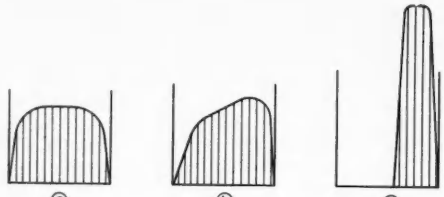


Fig. 2.

with a central portion of constant diameter with two toothed hubs for the gear couplings. For critical-speed evaluations, this shaft portion can be replaced by an equivalent mass $M = M_h + M_s/3$ at the position of the inner hub, M_h being the mass of one hub, and M_s the mass of the constant-diameter shaft portion. This is justified by considerations of kinetic energy, assuming that the amplitude of motion from the inner hub to the outer hub decreases linearly to zero.

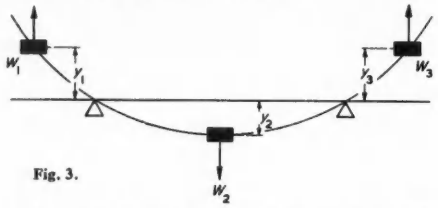


Fig. 3.

As an example of the effect of overhung masses, it has been found that, in the case of a high-pressure turbine with supports assumed at the inner edges of the bearings, the critical speed N_c was 7090 rpm, neglecting overhung masses, and 6540 rpm, with overhung masses ; with supports assumed at the centre of the bearings, these figures were respectively 5650 and 5510 rpm. In the case of an intermediate-pressure turbine with supports assumed at the centre of the bearings, the critical speeds were 5630 rpm, neglecting overhung masses, and 5430 rpm, with overhung masses.

Disc Effects (Inertia Couples) :—

When a steadily rotating disc is moved out of its normal position, a gyroscopic couple occurs. In bending vibrations, there is another such couple, due to the discs, which has no particular designation. The effects of both couples are denoted in the following as " disc effects ".

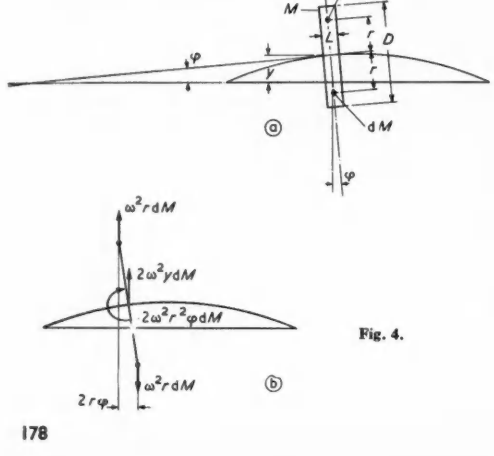


Fig. 4.

Consider a portion of the rotor, of mass M, represented as a disc of diameter D and thickness L. When the shaft axis deflects, owing to unbalance, the disc is inclined at an angle φ relative to the vertical (Fig. 4a). If two opposite mass elements, at a distance r from the centre of the disc, are denoted by dM, the deflection being y, they introduce centrifugal forces, as follows :—

$$dM\omega^2(r\cos\varphi - y) \quad \text{and} \quad dM\omega^2(r\cos\varphi + y)$$

or, with $\cos\varphi \cong 1$, $dM\omega^2(r-y)$ and $dM\omega^2(r+y)$.

These forces reduce to a resultant force $2\omega^2 y\, dM$ and a couple $2\omega^2 r^2 \varphi\, dM$ (Fig. 4b). Summating over the entire disc, a centrifugal force $M\omega^2 y$ and a couple $J\omega^2\varphi$ are obtained, where $J = Mk^2$ = moment of inertia of disc relative to a diametral plane, k being the radius of gyration. The couple is a " righting couple ", which tends to reduce the deflection due to centrifugal force, i.e., to raise the critical speed, which has been calculated without taking into account the couple.

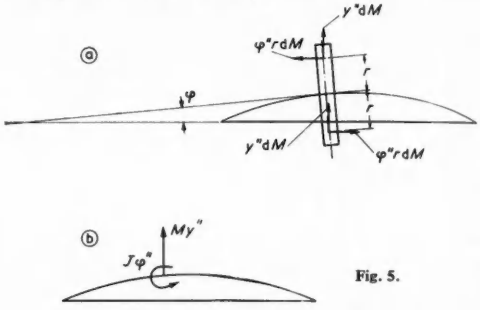


Fig. 5.

Now, consider the same disc, this time with its natural bending vibration. If the couples are neglected, the natural frequency coincides with the whirling speed of the rotor. At any instant, the mass M is in dynamic equilibrium, owing to its inertia force and the elastic restoring force of the shaft. For two symmetrical mass elements dM (Fig. 5a), the inertia force consists of two components $y''\, dM$ (where $y'' = d^2y/dt^2$), parallel to the axis and in the same direction, and two components $\varphi'' r\, dM$ (where $\varphi'' = d^2\varphi/dt^2$), parallel to the axis, due to the angular displacement, and forming a couple $dM\,\varphi''\, r^2$.

For the entire disc, an inertia force My'' and an inertia couple $J\varphi''$ are thus obtained, oriented as shown in Fig. 5b. It is evident that the inertia couple tends to increase the value of the deflection, i.e., to lower the natural frequency. Thus, the disc produces two opposing effects, i.e., (1) it raises the critical speed, and (2) it lowers the natural frequency, so that these two critical conditions no longer coincide when the disc effect is noticeable. If the variations due to disc effects are small, they are equal in absolute value, but if the effects are appreciable they are no longer equal.

For turbine rotors, disc effects are generally hardly apparent, because the main masses are situated in the middle region of the shaft, so that in practice the masses deflect perpendicularly to the line of the non-deformed axis. Moreover, for marine turbines, neglect of disc effects gives additional security, since these turbines always run at speeds below their first critical speed.

Changes in Shaft Section :—

A gradual change in shaft section can be evaluated by the usual formulae for shaft sections with a variable

second moment of area. For sudden changes in section (shafts of unequal diameters with a small fillet) a good approximation is obtained by introducing an equivalent transition in the form of a 45-deg. taper extending from the end of the smaller shaft portion into the larger shaft.

In the case of a bladed portion of the shaft, with alternate sections (of diameters D and d, respectively, d being also the shaft diameter), the width of these sections is approximately equal in value to the difference in radius. In this case, it can be considered that the stress distribution is not affected by the presence of the projecting portions, and the shaft can be treated as a single continuous plain shaft of diameter d.

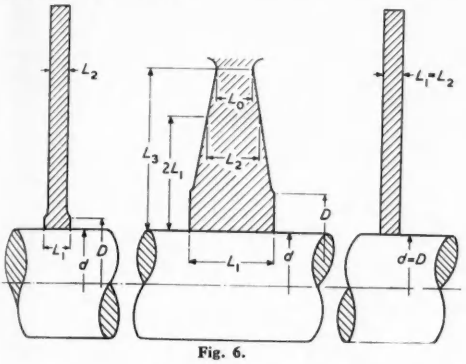


Fig. 6.

If a disc is integral with the rotor (Fig. 6), the second moment of area of the corresponding shaft section should be divided by a value K less than unity, taken from Figs. 7 and 8, which are based on an investigation by Eck*. From the ratio L_2/d (Fig. 7) the correction factor x is determined. Then, with the values D/d (hub diameter/shaft diameter) and L_1/L_2 (hub width/disc width) the factor y is obtained in Fig. 8. Finally, the required K-value is determined from $K = (y-x)/(L_1/L_2)$.

For tapering discs, L_2 is taken at the distance $2L_1$ above the shaft (Fig. 6) if the minimum thickness L_0 is at a distance L_3 greater than $2L_1$; however, if $2L_1$ is greater than L_3, L_0 should be used in place of L_2 for the corresponding ratios, i.e., L_0/d and L_1/L_0.

Modulus of Elasticity:—

The value of the modulus of elasticity E of the rotor varies for different turbines; along the rotor it decreases from the steam inlet to the last row of blades. The glands and bearings also heat up through conduction. According to work recently carried out in Great Britain, the temperature in a section of a drum-type rotor is very nearly equal to that of the steam passing through the blades.

A considerable amount of data has been published on the variation of E as a function of temperature. Unfortunately, the values given by various authors show very little agreement. The most likely values of E are 30×10^6 psi at 20°C, 27×10^6 psi at 150°C, 26×10^6 psi at 250°C, and 25×10^6 psi at 375°C.

Thus, for high-pressure turbines, in the sections after the gland on the inlet side, the stiffness of which has a marked effect on the deflection, the temperature is around 300°C and E is about $25{\cdot}5 \times 10^6$ psi. If this decreased value due to temperature were disregarded, the stiffness might be 10% too high. For an I.P. turbine this difference might be 5%, and for a L.P. turbine 2%.

* B. Eck: *Zeits. V.D.I.*, Vol. 2, No. 2, Jan. 14, 1928.

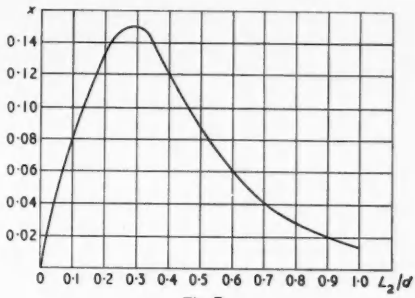


Fig. 7.

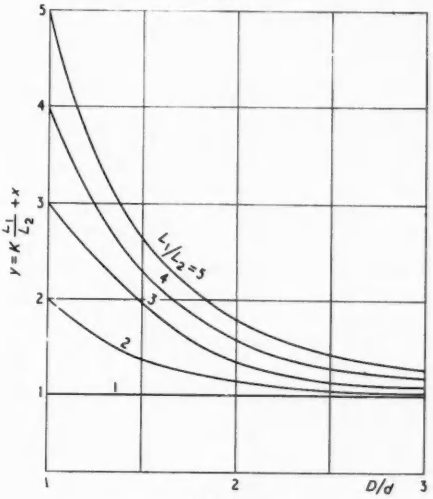


Fig. 8.

SIMPLIFIED PROCEDURE

For maximum accuracy it is advisable to take into account the various factors described above in evaluating a critical speed. However, if the general features of various turbines are basically similar to those of a turbine previously studied in detail, a simplified procedure may be used, in which the calculated critical speed is increased or decreased by the following factors.

Assumptions	Types of Turbine		
	H.P.	I.P.	L.P.
(1) Supports assumed at inner edges of bearings	1·05	1·05	1·14
(2) Overhung masses neglected	1·10	1·10	1·06
(3) Disc effects neglected	0·99	0·99	0·99
(4) Bladed portions of shaft treated as plain shaft sections	1	1	1
(5) Modulus of elasticity taken as 30×10^6 psi	1·10	1·05	1·02
Total factor (product)	1·26	1·20	1·22

As it is required that the maximum service speed N_s should be determined in such a way that N_c/N_s is at least 1·20 to 1·25, in order to keep away from the flanks of the resonance curve, it can be said that in practice a good margin of safety will be obtained if the simplified method gives a value of N_c/N_s of at least 1·5.

Calculation and Measurement of Critical Speeds

After determining the constants of the system, and deciding on the assumptions to be used (regarding bearing supports, disc effects, etc.), it is possible to calculate critical speed by means of one of the classical methods, of which those giving the most satisfactory results in practice are Stodola's method, Rayleigh's method, and the static deflection method.

As stated, apart from a small correction for the disc effect, the critical speed coincides with the natural frequency of the turbine rotor. This gives the possibility of checking the critical speed of a rotor before the turbine is assembled. The rotor is placed on two rigid V-blocks and excited with a variable-frequency vibrator until resonance conditions are obtained. Pick-ups are used to determine the amplitude of vibration at various positions.

For vibratory forces of 13 to 16 lb, which are sufficient to excite rotors weighing up to 2 tons, it is useful to employ an electromagnet, fed from a variable-frequency a.c. supply. It should be noted that, if F is the supply frequency, the attracting force will occur at a frequency $2F$. The current can be provided by a small pole-commutator alternator (with 6 or 18 poles). The excitation frequency can be determined with a good tachometer.

For forces with a peak value not much greater than 4 lb, an electrodynamic vibrator can also be used. Basically, this consists of a moving coil rigidly connected to a rod in contact with the rotor under test. The coil receiving alternating current is acted upon by a permanent magnet forming the stationary mass of the vibrator. The current is supplied from a low-frequency generator and amplifier. The range of frequencies extends from 3000 to 10,000 cps. The rod and coil system weighs about 5 oz. The electronic equipment includes pick-ups, a measuring bridge, an oscilloscope or valve voltmeter, and possibly an electronic switch.

The pick-up indicates either "absolute" or "relative" values. For absolute values, the pick-up is held by hand on the shaft or clamped to the shaft. Whereas its housing vibrates with the rotor, its seismic mass (i.e., the moving coil) has a very low natural frequency and can be regarded as fixed in space, so that absolute values are obtained. For relative values, the rod attached to the coil is in contact with the testpiece. The coil is elastically suspended in the air-gap of the pick-up housing, which is mounted on a non-vibrating bracket. In both cases, the output signal is proportional to the vibration frequency and has to be passed through an integrating circuit. Pick-ups at various positions are useful to indicate the vibration amplitude of overhung masses of the rotor. The pick-ups are capable of indicating vibrations of the order of micro-inches and can be calibrated, if necessary, for amplitudes by means of a measuring bridge. Finally, it may be noted that a rotary switch is useful for comparing on an oscilloscope the pick-up output with that of the vibration generator, in order to verify whether or not the pick-up signal is due to a harmonic of the excitation.

In the tests, it is necessary to ascertain with the aid of pick-ups that the bearing supports are sufficiently rigid. For high rigidity, the supporting arrangement may consist, for instance, of V-blocks bolted to cast-iron masses embedded in concrete. If vibration is indicated at the supports, these should be stiffened until their amplitude is negligible. It is advisable to compare the amplitude of the shaft vibration at the bearing with those of the bearing bracket and the test-bed. In investigating the effects of overhung masses, it may be necessary to add a steel disc representing the equivalent mass of the reduction gear at the coupling end. It should be borne in mind that, although the experimental frequency thus obtained takes account of changes in shaft section, disc effects, etc., it does not represent the value occurring at working temperatures when the modulus of elasticity is altered. Moreover, even with apparently very rigid supports, it may be 5% lower than the true value with infinitely stiff bearing conditions.

Critical Speeds of Turbines in Marine Installations

In marine installations, one of the supports of the turbine casing is rigidly bolted to the foundation, whereas the other is allowed a certain degree of flexibility, to enable it to yield to deformations caused by the ship's hull or by structural loading. To study the influence of these factors on critical speeds, two cases are analysed below, one being the general case in which both rotor supports have a certain flexibility, and the other a special case in which only one bearing support is flexible.

(1) *Both Rotor Supports are Flexible :—*

Consider a simple system, with a mass m_0 mid-way between the supports and concentrated masses m_1 and m_2 at the supports (Fig. 9), O-O being the rest position of the rotor. Let z_1, z_2 = radial (bending) displacements of supports, y = deflection of rotor relative to the line joining m_1 and m_2, K_1, K_2 = bending stiffnesses of supports, and K_0 = bending stiffness of rotor shaft.

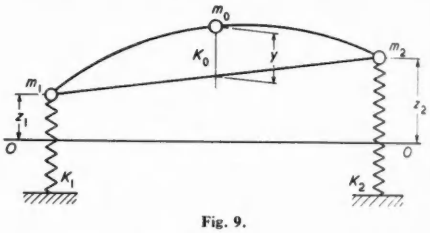


Fig. 9.

The natural vibrations of each separate sub-system can be represented as $\omega_0^2 = K_0/m_0$ (rotor on rigid supports), $\omega_1^2 = K_1/m_1$, and $\omega_2^2 = K_2/m_2$.

In the combined system, the equilibrium equations of the inertia forces and restoring forces are

$$m_0\omega^2[y + (z_1+z_2)/2] = K_0 y,$$
$$m_1\omega^2 z_1 = K_1 z_1 - (K_0 y/2), \text{ and}$$
$$m_2\omega^2 z_2 = K_2 z_2 - (K_0 y/2)$$

From these equations, y, z_1, and z_2 can be eliminated so as to obtain the frequency equation of the system, i.e.,

$$f(\omega) = \omega^6 - \omega^4\left[\omega_0^2 + \omega_1^2 + \omega_2^2 + \frac{K_0}{4}\left(\frac{1}{m_1} + \frac{1}{m_2}\right)\right]$$
$$+ \omega^2\left[\omega_0^2\omega_1^2 + \omega_0^2\omega_2^2 + \omega_1^2\omega_2^2 + \frac{K_0}{4}\left(\frac{\omega_1^2}{m_2} + \frac{\omega_2^2}{m_1}\right)\right]$$
$$- \omega_0^2\omega_1^2\omega_2^2 = 0.$$

If $\omega_0 < \omega_1$, or $\omega_0 < \omega_2$ (one or both supports fairly rigid), the resulting ω-value is lower than ω_0. If ω_0 is greater than ω_1 and ω_2 (both supports fairly flexible), the resulting ω-value is greater than ω_0. The behaviour of the entire system becomes more similar to that of a free body, and the system vibrates with two nodes at some distance from the ends. Each of the frequencies ω_0, ω_1, and ω_2 can be determined experimentally for the separate parts and then substituted in the above equation to determine ω.

(*Concluded on page* 184)

Drilling Machine with Vibrating Table for Small-Diameter Holes

By M. N. Ulitin and I. G. Kuritzyn. (From *Avtomobilnaya i Traktornaya Promyshlennost*, No. 1, 1956, pp. 36–38, 7 illustrations.)

Designed for drilling holes of 0·2, 0·25, 0·45, and 0·6 mm in diameter to a depth of between 5 and 10 diameters in medium carbon steel, low-alloy steel, and brass, the machine consists essentially of a specially developed drill-head and an electromagnetically vibrated work-table. The drill spindle rotates at between 23,000 and 30,000 rpm, and the table vibrates at a frequency of 50 cps, with an amplitude of between 0·02 and 0·09 mm. The steel body of the table ensures the necessary rigidity, serves as a base for mounting all the components of the installation, and takes the axial load during drilling.

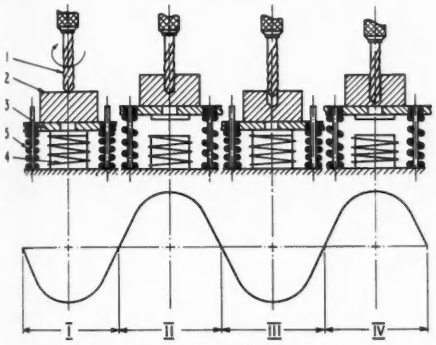


Fig. 1. Diagram of drilling cycle.

The drill-head incorporates a high-speed electric motor, which is attached to the body of a sliding assembly travelling along two guides. Advance of the slide is effected by a feed cam, and withdrawal by two springs coiled around the guides. The cam transmission contains a reduction gear driven by an electric motor supplied with 110-V d.c. The feed cam is located on the output shaft of the reduction gear. The complete drilling cycle is accomplished during one cam revolution.

The feed motor is supplied via a dry rectifier in a circuit containing a voltage regulator for speed control. The drill motor is supplied from the mains via a transformer and dry rectifier, which, through a resistance, feeds a rotary converter generating 500-cps alternating current. The electromagnets in the vibrator are operated by current of industrial frequency at 127 V, variations in vibration amplitude being effected by means of a resistance.

In tests carried out with this drill, table amplitude was optically measured under a magnification of × 135. A counter was fitted to the machine, so as to be able to register the number of holes completed before changing the drill.

Fig. 1 is a diagram of the drilling cycle. In considering the relation between the positions of the drill (1), the work (2), and the table (3), and the operation of the electromagnet (4) and the spring (5), suppose the rate of feed of the drill to be 10 microns in every 0·02 sec and the amplitude of vibration to be 35 microns. In (I) (Fig. 1), the table with the work is in the extreme lower position, in which the drill engages the work (commencement of operation), the depth of drill penetration being zero. In (II), the table with the work is in the extreme upper position, i.e., half a cycle has elapsed, and the drill has penetrated 40 microns. In (III), at the end of the second half of the cycle, the drill point has advanced by 10 microns, so that it is now 25 microns from the bottom of the hole, as the work has dropped by 35 microns. In (IV), the table is once more at the extreme upper position, so that the drill has now penetrated an additional depth equal to twice the feed per cycle. Thus, periods of drill penetration alternate with periods of chip disintegration.

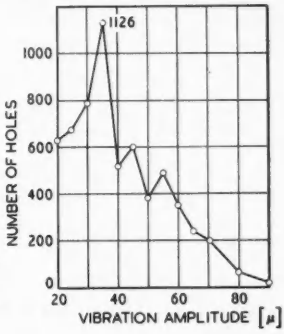


Fig. 2. Number of holes drilled in 0·3% carbon steel as a function of vibration amplitude.

Fig. 2 is a graph of the number of 0·6-mm holes

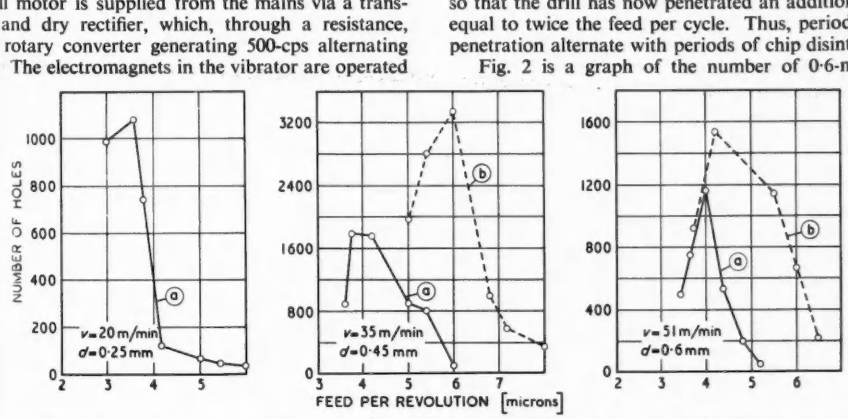


Fig. 3. Number of holes, 3 mm in depth, drilled in (a) 0·3% carbon steel and (b) brass, as a function of feed per revolution, for holes of different diameter d and with different cutting speeds v.

drilled to a depth of 3 mm before the drill becomes blunt as a function of vibration amplitude, for 0·3% carbon steel, and has a sharp maximum at an amplitude of 35 microns, under the representative conditions examined, i.e., with a spindle speed of 25,000 rpm and a feed per revolution of 2·4 microns. Fig. 3 gives comparative results obtained with 0·3% carbon steel and brass, and shows the number of holes, each 3 mm in depth, as a function of feed per revolution, for holes of different diameter d and with different cutting speeds v. Here again, a sharp maximum is apparent in all cases, its position and magnitude depending on the material.

Compared with conventional drilling, the number of holes drilled before resharpening or renewal of the drill was found to be increased by at least four times. Thus, for instance, when drilling holes of 0·25 mm diameter it was found that, while the average number of holes drilled by conventional methods was about 170, no less than 1100 holes of the same diameter could be drilled on the vibrating type of machine before renewal of the drill became necessary. Furthermore, it was found that cutting speed was increased by a factor of at least 3.

Tests were also carried out to establish variations in hole dimensions. In the case of holes of different diameters, ranging from 0·2 to 0·6 mm, it was found that the vibrating technique produced holes enlarged by about 10% of the diameter, with negligible variations. It is believed, however, that this enlargement can be substantially reduced by improving the design of the guides of the vibrating table.

GERMANY

Dielectric Properties of Insulating Varnishes

By K. Potthoff and R. Vees. (From *E.T.Z.*, Vol. 77, No. 3, February 1, 1956, pp. 65-69, 15 illustrations.)

Insulating materials have been divided into various temperature classes, according to the maximum permissible temperature to which they can be exposed for long periods without deterioration of their insulating properties. The basic data are usually determined by accelerated ageing at an elevated temperature, followed by tests of dielectric strength and bending strength. In addition, the weight loss of the specimen after storage at high temperature is determined.

The above tests do not make it possible to follow and indicate the changes due to the ageing process without destruction of the material. This information can, however, be obtained by measurement of the dielectric constant and the loss factor as functions of temperature. Although knowledge of these two quantities alone is not sufficient to assign a material to a definite temperature class, the results derived from the non-destructive method give a more detailed picture of the processes occurring in the material at high temperatures, as will be shown in the following, in which the varnish-covered wires considered are of classes E, B, and F, which correspond to maximum permissible working temperatures of 120, 130, and 140°C, respectively.

In the test method used, specimens of varnish-covered copper wire, 12 cm long, were coated over a length of 10 cm with colloidal graphite. The copper conductor forms one electrode of a capacitor, the other electrode being provided by the graphite coating, while the varnish is the dielectric. Graphite deposition, instead of metallization, has the advantage of being permeable to moisture and follows surprisingly well the shrinkage deformations of the layer of varnish, without preventing the diffusion of decomposition products.

The frequency at which the a.c. measurements should be carried out was carefully considered. It would have been easy to use a frequency of 50 cps, but it was considered preferable to take all measurements at 800 cps, because it was feared that the shape of the curve of the loss factor tan δ as a function of temperature, which is determined by dipole losses, might otherwise be appreciably altered by conductivity losses. Even at 800 cps, the curves of tan δ and capacitance C, as functions of temperature θ, seemed slightly shifted towards higher temperature values.

Measurements were made with a Schering bridge provided with a Wagner earth, the output being fed into an amplifier tuned to 800 cps. The values were measured at temperatures up to 150°C, or even higher. In previous work, the specimens had been heated by a heat-circulating system forming part of the holding fixture and controlled by a thermostat. For these new tests, this system was replaced by an electric heating arrangement, with temperature indication by means of thermocouples.

In principle, a complete programme of ageing tests could have been carried out on a single piece of wire 12 cm in length. The tests, however, were made with new specimens for each different period of ageing and temperature ; moreover, three specimens were subjected, in most cases, to each ageing treatment. In view of the large number of types of wire currently manufactured, there were hundreds of specimens which had to be kept carefully separate for tests and summarized reports. For storage and identification, therefore, a honeycomb arrangement of thick copper sheet was designed around a suitable drying oven ; each specimen was placed in a folding box-type container of aluminium foil, which was then inserted into its particular cell in the honeycomb structure. The heat capacity of this heavy copper honeycomb mass was so great that the oven temperature was insensitive to any influences likely to occur when its door was opened, and a substantially constant temperature was maintained over the entire oven cross-section.

The tests were carried out on groups of wires with decreasing temperatures, starting in each case with the highest temperature, i.e., the ageing temperature. For specimens not subjected to ageing treatment, the tests were performed rapidly at the highest temperatures, to avoid changes in the dielectric properties.

Test Results

Preliminary tests showed that there is considerable improvement in the insulating quality of varnish-covered wires now available, as compared with that of wires produced around 1943. Fig. 1 shows the loss-factor curves of three varnish-coated wires plotted against temperature. The different shapes of the curves are due to the multiplicity of synthetic materials employed nowadays by varnish manufacturers. Curve (2) represents a wire with a polyvinyl-formal type of varnish, tested without previous ageing treatment. The curve has a maximum at 126°C ;

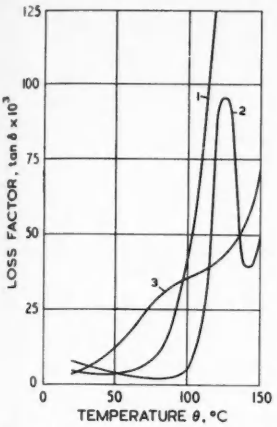


Fig. 1. (left) **Loss factor as a function of temperature for wires coated with various insulating varnishes.**

(1) Silicone-modified varnish.
(2) Polyvinyl-formal varnish.
(3) Phenolic-resin type of varnish.

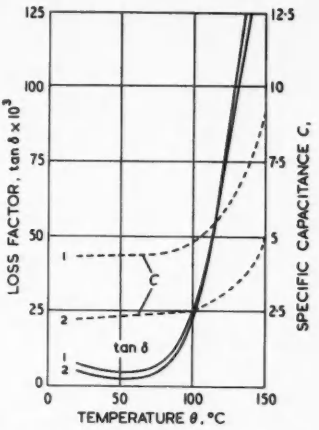


Fig. 2. (right) **Loss factor and capacitance [10⁻⁹F/m] as a function of temperature for a single-layer (curves (1)) and double-layer (curves (2)) coating of varnish.**

beyond this temperature, conductivity losses occur. Curve (3) for a wire with a phenolic-resin type of varnish shows a fairly flat relative maximum, while curve (1) for a wire with a silicone-modified varnish still shows evidence of high losses due to the organic component.

From large numbers of measurements it was possible to prove that the shape of the curve of tan δ as a function of temperature is characteristic for each type of product. Fig. 2 shows the loss factor and capacitance curves of single-layer and double-layer varnished wires from one supplier. As expected, the difference appears only in the capacitance curves, whereas the loss-factor curves coincide to a satisfactory extent. Baking would alter the shapes and shift the curves towards the right-hand side of the diagram, but these would not be appreciably modified by the degree of baking.

The results given in Figs. 1 and 2 indicate that requirements were fulfilled to a sufficient degree to enable ageing tests to be carried out on this basis. Exploratory tests of this kind, made in 1943 with lower thermal loads, had in most cases shown losses increasing with temperature. These were interpreted as conductivity losses in the decomposition products. The new tests showed that, at somewhat higher ageing temperatures, the loss factor decreases, with very few exceptions, because the decomposition products, which determine the loss angle, diffuse out of the varnish and progressive polymerizations restrict the mobility of the remaining dipoles.

Fig. 3 shows the curves for a wire with varnish on a polyvinyl-formal base. Wires coated with this varnish were aged at 150°C during periods of 1, 2, 4, 8, and 16 days ; the loss factor and capacitance were then measured with decreasing temperatures and plotted, as shown. In order to avoid interruptions in the ageing process, separate specimens were employed for each storage period, and each test point was determined as the mean value of three measurements on different specimens, although this further confirmation was in most cases unnecessary.

The temperature dependence of the loss factor and capacitance can be tentatively explained as follows : In view of the complicated structure of the polyvinyl-formal base, an appreciable dipole moment can be expected. The mechanical softening of the material begins at 110°C ; this may also be regarded as the temperature at which the dipoles come into motion. When the wire has not been subjected to an ageing treatment, a clearly defined maximum of the loss factor, undistorted or blotted out by conductivity losses, is obtained.

With an increasing period of ageing, the groups capable of performing oscillations are destroyed and diffuse out of the material ; this results in shrinking and in loss of weight of the varnish. At temperatures below the absorption region, capacitance increases, since the layer of lacquer gradually becomes thinner. The rate of increase of capacitance, however, decreases because the number of dipoles becomes smaller. The capacitance maximum is displaced towards higher temperatures because dipole motion is impeded in the shrunken varnish. After an ageing period of 16 days at 150°C, there is a material on the wire which evidently no longer has anything to do with the original material. From this, however, nothing can be inferred regarding the behaviour of the material at temperatures of 120°C or less.

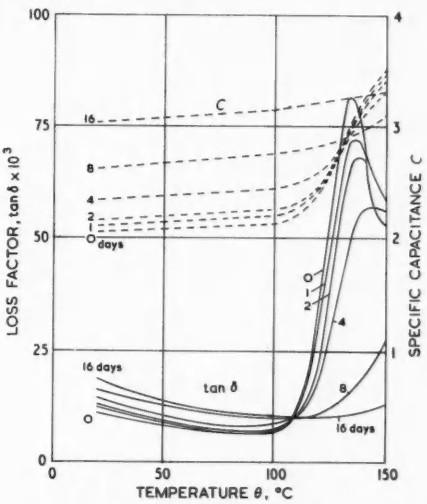


Fig. 3. **Loss factor and capacitance [10⁻⁹F/m] as a function of temperature for a polyvinyl-formal varnish on a wire of 1 mm diameter, aged at 150°C for periods up to 16 days.**

When no ageing has taken place, the wire still has a relative dielectric constant $\varepsilon_r = 3$ at room temperature. Therefore, it is reasonable to expect a second absorption region at low negative temperatures, below 0°C, and during the ageing process this region probably shifts towards higher temperatures. This can be recognized from

the falling portion of the curves of the loss factor tan δ in Fig. 3, for which the decreasing values were determined at and above room temperature. A slight rise in capacitance in this range also indicates the absorption region.

The most noticeable feature is the marked rise in capacitance with increased ageing (Fig. 3), which, from what has been said above, should correspond to a considerable loss in weight. It was, in fact, found that the relative percentage loss in weight of the material was 20% after 1 day, 28% after 2 days, 33% after 3 days, and 41% after 8 days. The decrease during the first 3 days is proportional to the square root of the time elapsed, and is less rapid thereafter. The straight line relationship for the various regions is as expected in diffusion processes. Relations of this type have since been confirmed by other investigators.

Further tests were made on wires coated with two types of varnishes, which, according to the suppliers, have a much higher temperature strength than the specimens used for Fig. 3. It was found that for these two varnishes the tan δ curves begin with lower values in the low-temperature region and rise to values up to or exceeding 250 × 10^{-3} at 150°C, without reaching their peaks at this temperature. The capacitance curves were found to be closer together for various ageing periods, in the lower temperature range, and also ascended towards higher values (from 4 to 10 × 10^{-9} F/m) at 150°C. Thus, for high-temperature varnishes, with increased ageing the regions of higher absorption are displaced towards higher temperatures ; the change in the dielectric constant at temperatures below the absorption region becomes considerably smaller. This is particularly applicable to silicone-modified varnish, as shown in Fig. 4, which refers to a varnish of German manufacture. The corresponding curves for an American-made silicone-modified varnish show somewhat higher capacitance values, and steeper tan δ-curves, with peaks not generally exceeding 50 × 10^{-3} in the region between 125 and 150°C. Both sets of results show, therefore, the progress attained with regard to temperature strength by means of insulation with silicone-modified varnish.

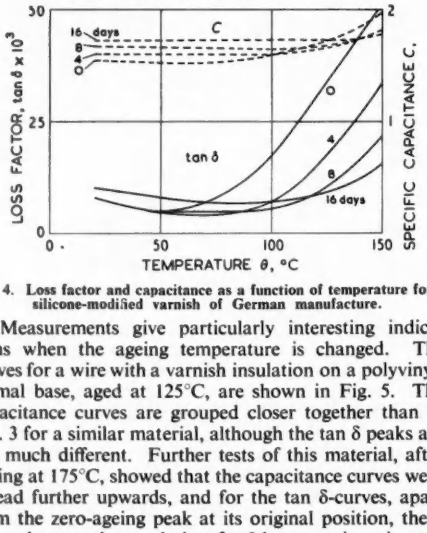


Fig. 4. **Loss factor and capacitance as a function of temperature for a silicone-modified varnish of German manufacture.**

Measurements give particularly interesting indications when the ageing temperature is changed. The curves for a wire with a varnish insulation on a polyvinyl-formal base, aged at 125°C, are shown in Fig. 5. The capacitance curves are grouped closer together than in Fig. 3 for a similar material, although the tan δ peaks are not much different. Further tests of this material, after ageing at 175°C, showed that the capacitance curves were spread further upwards, and for the tan δ-curves, apart from the zero-ageing peak at its original position, there was only one other peak, i.e., for 8 hours ageing, situated at 150°C with a value of about 45 × 10^{-3}. Thus, after a

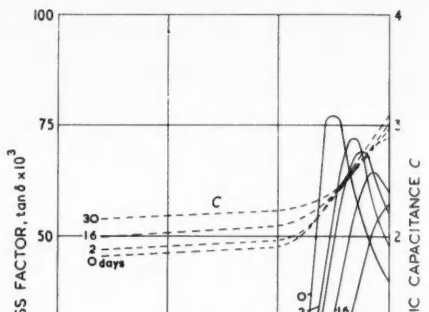


Fig. 5. **Loss factor and capacitance as a function of temperature for a polyvinyl-formal varnish on a wire of 0·6 mm, aged at 125 C.**

period of 30 days at 125°C, the dielectric properties of this wire showed very little alteration, whereas at 175°C the same slight alteration was produced in about 12 hours. From these results, it can be calculated approximately that the ageing effect (or ageing rate) is doubled by an increase in temperature of 8°C. Some minor irregularities, such as the very low losses around the 100°C region, still have to be clarified (Fig. 5).

In the above, it has been shown that the method is suitable for the approximate identification of varnishes and for a non-destructive study of the ageing process. It should be possible to use this method for the temperature classification of varnishes, after collecting sufficient data. Further work will serve to determine the influence of additional coats of varnish, as well as to clarify the decomposition process and to obtain data on moisture sensitivity with ageing.

Calculation and Measurement of Critical Speeds of Turbine Rotors.

(*Concluded from page* 180)

In addition to these vibrations due to the critical speed of the rotor, two other vibrations of the turbine oscillating as a single mass, at frequencies near each of the natural frequencies of the supports, can be observed.

(2) *One Support is Rigid, the Other Flexible* :—

Let $z_1 = z$, and $z_2 = 0$. The equilibrium equations become $m_0\omega^2[y+(z/2)] = K_0 y$, and $m_1\omega^2 z = K_1 z - (K_0 y/2)$, so that the frequency equation is in this case

$$\omega^4 - \omega^2[\omega_0^2 + \omega_1^2 + (K_0/2m_1)] + \omega_0^2\,\omega_1^2 = 0.$$

The roots are ω_A and ω_B. If $\omega_0 < \omega_1$, the resulting frequency is lower than the rotor frequency ($\omega_A < \omega_0$). If $\omega_0 > \omega_1$, i.e., if the flexible bearing is less rigid than the rotor (e.g., rubber-mounted bearing), the resulting frequency is higher ($\omega_B > \omega_0$).

It has been verified by tests that the rotor frequency ω_0 (or its modified value ω_A) is always present in marine installations. In addition, there are one or two other frequencies due to the supports, with somewhat different values, according to whether the vibrations are excited in the horizontal or in the vertical direction.

Superconductivity

By A. WEXLER. (From *Metal Progress*, Vol. 69, No. 3, March 1956, pp. 89–93, 4 illustrations.)

LOW-TEMPERATURE research is a scientific and engineering field of considerable and growing activity. It opens up for exploration a literally limitless temperature range, down to within a few tenths of a degree of 0°K, or absolute zero. In a given temperature range the abundance of new phenomena depends not on the number of degrees of temperature involved, but rather on the ratio of the absolute temperatures covered. From this point of view, a more realistic picture of the importance of a given temperature interval is obtained by considering the logarithm of the absolute temperatures; the infinite extent of the low-temperature field then becomes apparent. More specifically, with simple liquid-helium techniques a temperature of 1°K can be reached quite easily—a temperature which is 1/300 of room temperature. To increase the absolute temperature by a factor of 300 upwards from room temperature would involve a temperature of 90,000°K.

The power of low-temperature research also lies in the effects of lowering the thermal energy of substances. Lowering the temperature greatly simplifies the physical processes that occur within a substance, so that low-temperature experimentation is a general tool for studying the electrical, magnetic, optical, thermal, and mechanical properties of substances.

One way by which this simplification occurs is through the reduction of the thermal agitation of the atoms comprising a substance; this often makes possible studies which would be exceedingly difficult, if not impossible, at high temperatures. For example, the role played by impurities in determining the electrical and thermal conductivities of metals is often masked at higher temperatures by the violently moving atoms, which, in colliding with the electrons, absorb most of the energy lost by them in passing through a metal. Lowering the temperature brings this atomic agitation almost to a halt, and the effects of the impurities as well as those of boundaries of the conductor can be observed.

Another example of great importance for the theory of metals is provided by a consideration of the specific heat of a metal—that is, the ratio of heat energy absorbed to the change in temperature. To understand the metallic state, the contribution to the specific heat by the electrons must be known. Only in the liquid-helium range can the masking effects of the specific heat of the atoms be eliminated, and that of the electrons be made to stand out.

Furthermore, the study of the temperature dependence of some property over a temperature range involving a large ratio of absolute temperatures often provides an insight into the processes underlying the property. For example, the study of the magnetic susceptibility of phosphors from room temperature down to 1°K has shed considerable light on the nature of activators—the impurities present in minute amounts and on whose presence the effectiveness of the phosphor depends.

There is yet another aspect of the lowering of thermal energy. Suppose that phenomena exist in nature so delicate that the thermal energy present in materials at ordinary temperatures prevents their appearance. The most striking example of such a phenomenon is superconductivity. A large number of metals and alloys, at temperatures below a certain transition temperature characteristic of each substance, completely lose their electrical resistance and, while in this superconducting state, are perfectly diamagnetic. In sharp contrast to superconductivity is the rise in electrical resistance at low temperatures, another baffling low-temperature phenomenon exhibited by a number of slightly impure metals. At low temperatures liquid helium itself undergoes changes in properties which in many respects are as spectacular as those shown by superconductors. It becomes "superfluid" and flows rapidly through the smallest openings. Its thermal conductivity also increases enormously, making it a better heat conductor than the purest metal.

At the temperature of liquid helium all other substances are solid, and oxygen and nitrogen resemble white sand at ordinary temperatures. The strength of low-carbon steel increases by a factor of five over that at room temperature but it becomes quite brittle. Certain dielectric materials have thermal conductivities at these temperatures as much as 60 times greater than that o copper at ordinary temperatures. The metal gadolinium, whose magnetic properties at ordinary temperatures are not unusual, is ferromagnetic at low temperatures with a saturation magnetization per unit mass 16% greater than that of iron.

USES OF SUPERCONDUCTORS

Of the low-temperature phenomena mentioned, superconductivity is perhaps the most interesting. When the temperature of a metal is decreased, its electrical resistance is lowered. The electron scollide with the atoms comprising the metal and give up to the atomic lattice some of the energy acquired by the electrons from the electric field. This transferred energy is, of course, the Joule heat loss. According to theory, an electron passing through a perfect lattice would lose no energy. The thermal motion of the atoms destroys the perfection of the lattice, and an ideal metal would be expected to have a resistance/temperature characteristic as indicated by curve (a) in Fig. 1. Actually, the electrical resistance of a metal does not drop to zero as absolute zero is approached, because there are imperfections due to chemical impurities and to physical imperfections of the metal structure. At low temperatures, where the scattering of electrons by the thermal motion of the atoms makes a negligible contribution to the resistance, the electrical resistance of a metal assumes a temperature-independent

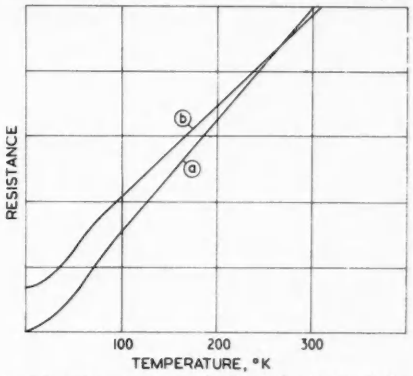


Fig. 1. **Effect of temperature on the electrical resistance of (a) a pure metal, and (b) an impure metal.**

value, called the residual resistance, which is a measure of the level of chemical and physical impurities, as shown by curve (b) in Fig. 1.

Despite more than forty years of experimental and theoretical study, the phenomenon of superconductivity has eluded an explanation based on first principles ; it ranks with the nature of nuclear forces as one of the major problems facing the theoretical physicist.

With regard to the important properties of superconductors, it has been found experimentally that to every temperature below the transition temperature there corresponds a value of the magnetic field which destroys superconductivity, and restores the normal resistance. Fig. 2 shows the critical field and temperature relation for a number of superconductors.

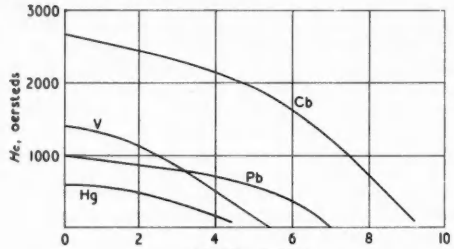


Fig. 2. Critical magnetic fields of some superconductive metals.

From the standpoint of certain possible applications —for example, as resistance-less windings in transformers—it is unfortunate that nature has imposed these limitations of magnetic field. The maximum field in which superconductivity can be maintained in a pure metal is 2600 oersteds for columbium.

The magnetic properties of a superconductor, like its electrical properties, are unique. From electromagnetic theory it could be predicted that, once a material is in the superconducting state, a magnetic field could not enter the bulk of the material because shielding currents would be induced in a thin layer at the surface of the perfect conductor by any applied external field. As long as the critical field, H_c, is not exceeded, the magnetic induction within the material should remain zero. If, however, H_c is exceeded and the field is then reduced below H_c, the induction in the material when it again becomes superconducting should remain "frozen" in. An entirely new phenomenon is actually observed ; the magnetic induction of a superconductor is zero and is independent of its magnetic history. This perfect diamagnetism is a totally unexpected property and, like the absence of electrical resistance, remains unexplained to this day.

Experimentally, " zero " resistance can be shown to be no greater than a certain amount, i.e., only an upper limit to the resistance can be established. However, this limit is very low ; below the transition temperature the resistance of a superconductor is no more than 1×10^{-15} of its value at room temperature.

The very low upper limit can be demonstrated quite easily if a ring, made of the material and cooled below the transition temperature, is exposed to a magnetic field in excess of the critical field at that temperature and if the field is then reduced to zero. As a result, thousands of amperes may be caused to flow in the ring and, judged from its magnetic effects, this huge current continues to flow for days with no measurable diminution.

More than 20 elements and a large number of intermetallic compounds become superconductors. Curiously enough, the best conductors, copper and silver, are not among them. In fact, a useful trick employed by low-temperature physicists is to copper-plate superconductors when one turn of superconducting wire must be insulated electrically from another. At temperatures near absolute zero, copper of the best purity available has a resistance only one-thousandth of its room-temperature value. Thus, its efficacy as an electrically insulating coating is based not on its absolute resistance, which is quite low, but rather on its resistance relative to that of the superconductor it insulates.

The element with the highest transition temperature (about 11°K) is technetium ; another element with a high transition temperature is lead (7·2°K). Other metals, such as cadmium, ruthenium and titanium, have transition temperatures within one degree of absolute zero. Incidentally, during the last decade extensive studies have been pursued in a temperature range within a few thousandths of a degree of absolute zero. The highest transition temperature (close to 18°K) for superconductivity so far observed is for the intermetallic compound Cb_3Sn. The search for high transition temperatures, which could provide important clues to the understanding of superconductivity, as well as bring practical application closer to realization, is continuing.

Up to the present time the rich store of low-temperature phenomena has been virtually untapped with respect to commercial applications. While it is not impossible that low-temperature techniques will one day be applied to heavy electrical equipment, the first application will probably come in specialized fields of instrumentation, such as in computers. Here, there is the promise of greatly decreasing the size of complicated equipment by the use of new types of tiny electronic elements.

One example of the use of low-temperature phenomena in special areas of instrumentation is the superconducting bolometer, which is used as a detector of radiant energy. A typical bolometer has a minimum detectable energy in a single flash of 2×10^{-6} erg and can be used as an alpha-particle detector which counts the particles and also gives an indication of their energy.

Another example of instrumentation using low-temperature techniques is to be found in liquid-helium and liquid-hydrogen bubble chambers. Superheated liquid helium and liquid hydrogen have been found to be very sensitive bubble chambers, giving tracks when exposed to ionizing radiation in a manner analogous with that of the more familiar cloud chambers.

The possibility of useful applications of low-temperature phenomena is among the less subtle reasons for the interest of the electrical industry in this field. In specialized fields, such as in gas separation and liquefaction, the applications have been in effect for many years. Low-temperature techniques have played an essential role in thermonuclear developments. Special containers whose temperatures can be maintained within a few degrees of absolute zero for hundreds of days—with practically no attention after initial loading with liquid-helium refrigerant—have been developed and are used in low-temperature work. Exactly when low-temperature techniques will be used on a commercial scale is largely in the hands of scientists and development engineers. Research is of value not only to the specialist in a pioneer field like low-temperature physics but also to those working in related fields, and the interactions of scientists, both within a given laboratory and through normal channels of scientific information, are essential.

Wide-Screen Cinema Projection Systems

By J. J. Kotte. (From *Philips Technical Review*, Vol. 17, No. 10, April 1956, pp. 299–302, 7 illustrations.)

In the past few years, various new wide-screen cinema projection systems have been developed. These may be divided into three types, i.e., the multi-projector or "Cinerama" system, the wide-angle anamorphic-lens system (of which "CinemaScope" is representative) and the wide-angle large-film or "Todd-A.O." system, which made its début in October, 1955.

The aim of all these new systems is to strengthen the impression of "realism" created by the film. The method used in the above three systems is to photograph a wider field of view by using wide-angle taking lenses and to take up more of the field of vision of the audience with the projected picture by widening the screen. In this connection, it should be noted that it is not sufficient to fill the larger screen merely by projecting a normal film which has been enlarged still further; this would only produce the same effect as if the audience were to sit nearer to the screen.

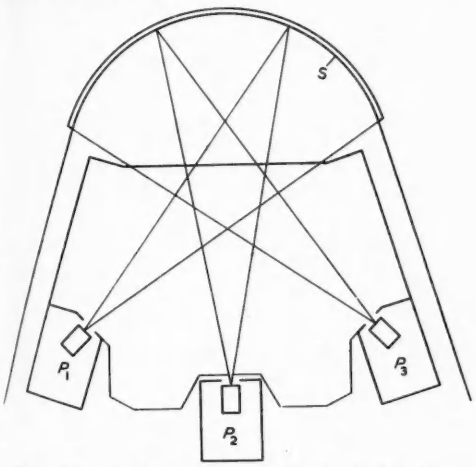


Fig. 1. Schematic diagram of the "Cinerama" projection system.

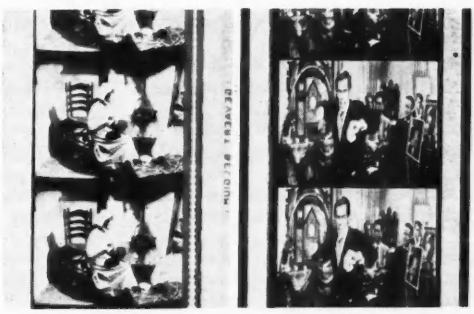
It is most desirable to combine the use of a wide screen with so-called stereophonic sound. The positions on the wide screen where the actions take place can vary so much that it would be distracting were the accompanying sound to come from just one fixed direction.

An increase in the picture angle at the filming stage has been taken furthest in the "Cinerama" system. In this system three cameras are used; these take adjoining pictures, giving a total picture angle of 146 deg. in filming. When these are projected, a wide curved screen is used, on which the three films are projected next to each other by three synchronized projectors (Fig. 1). It is true that the great majority of the audience will see the picture at an angle considerably less than 146 deg., but experience shows that this is not objectionable.

From the point of view of audiences, the greatest disadvantage of the "Cinerama" system is that the two dividing lines on the screen, where the pictures join, have not as yet been successfully eliminated. Furthermore, the brightness and colour of the three individual films are never absolutely alike, and, in addition, every picture tends to "dance" to some degree. The reason for this latter defect is due to the fact that the positions of the frames on the film and the transport mechanisms of the projectors are never quite perfect, so that consecutive frames never occupy exactly the same position in the film gate. As the dancing effect is not the same for each of the three films, they can be seen to quiver with respect to each other at the picture boundaries. Possibly even more distracting is the fact that at a picture boundary the faults in the picture, though slight, change in a discontinuous manner. This can cause, for example, a long object situated across the width of the screen to show a kink at a picture boundary.

Apart from the complication and expense of using three cameras for filming and three synchronized films and projectors for screening, "Cinerama" has the further disadvantage that the three projection rooms P_1, P_2, and P_3 (Fig. 1) must be located in the auditorium itself, so that a considerable number of seats may have to be given up to make room for them. Projection is not possible from rooms situated high up, as the light beams would strike the screen obliquely, and horizontal lines, for instance, would be reproduced as curved lines because of the curvature of the screen. Moreover, the whole arrangement is very complicated, and several technicians are necessary to operate it.

In the "CinemaScope" system, which eliminates the drawbacks of multi-projectors, only one film and one projector are used. Normally, the system uses 35-mm film,* in which, by means of an anamorphic lens, the picture is compressed in a horizontal sense when photographed. Fig. 2a shows a standard 35-mm picture, while Fig. 2b shows a 35-mm "CinemaScope" picture, in which the distortion or horizontal compression is clearly visible. During projection, this distortion is eliminated by the use of a similar anamorphic lens, which expands the picture horizontally, so that the natural relationships are restored. The film can have one optical sound-track (similar to that shown in Fig. 2a) or 4 magnetic tracks (the two black bands shown on each side of the film in Fig. 2b).



(a) (b)

Fig. 2. Strips of 35-mm film, (a) normal, with optical sound-track, and (b) "CinemaScope", with 4 magnetic sound-tracks.

With "CinemaScope" the picture angle during filming is about 90 deg. Compared with "Cinerama", with its angle of 146 deg., "CinemaScope" provides the

* "CinemaScope" on 55-mm film is now being shown in London. By virtue of the larger frame size (4 times the area of that of the 35-mm frame), increased image sharpness, particularly at the edges of the screen, is manifest. However, as the screen itself remains substantially the same, virtually no increase in realism is obtained.—Ed. E. D.

least degree of realism of all the new systems. Certainly, " Cinerama ", despite its drawbacks, is impressive, to say the least.

The " Todd-A.O." system (derived from Todd, who advocated it, and the American Optical Co., who developed the necessary wide-angle lens) combines the advantages of the one-film, one-projector " CinemaScope " system with the impressiveness of " Cinerama ". The special wide-angle taking lens has a picture angle of 128 deg. (still retaining, however, a comparatively large numerical aperture). A film taken with this lens consequently covers an area only slightly less than that of the three " Cinerama " cameras combined. Such a film can be projected onto a wide, curved screen, and this produces, with a single projector, a similar effect to that of " Cinerama ". Incidentally, the picture angle of the projector does not need to be made specially large.

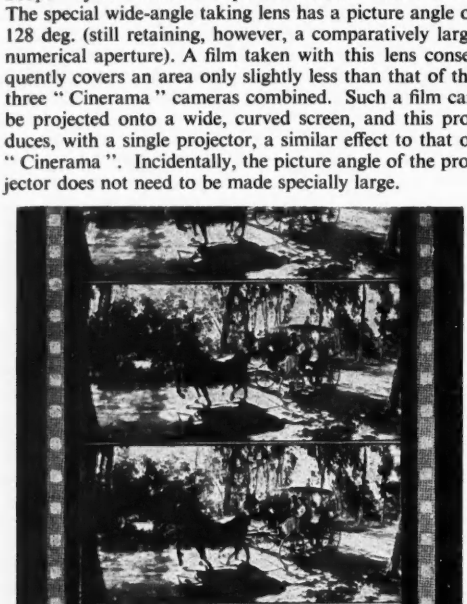


Fig. 3. Strip of 70-mm film used in " Todd-A.O." system, with 6 magnetic sound-tracks.

This special objective forms the nucleus of the " Todd-A.O." system, which, however, has other characteristic features. One of these is that it has completely broken with tradition by using 70-mm film in place of 35-mm, and at the same time the frame frequency has been increased from 24 to 30 frames per second. The higher frame frequency produces smoother motion and lessens flickering in the picture reproduced on the screen. This is very desirable, for the eye is most sensitive to flickering at the periphery of the field of vision and, as a result, flickering on a wide screen might become noticeable.

The problem of obtaining a sufficiently bright picture on the large screen is greatly simplified by the wide film, since the area of the frame on 70-mm film can be made 3·5 times as large as that on normal 35-mm film. For the same luminous intensity on the film, 3·5 times as much light strikes the screen. In addition, the higher frame frequency contributes to less heating of the film. Another important advantage is that the big screen can be filled without abnormally large magnification. With the small frame of 35-mm film, the grain of the emulsion would be visible and would tend to blur the image.

Fig. 3 shows a strip of 70-mm film, in which it will be noticed that the height of a frame is 5 times the perforation spacing (as against 4 for standard 35-mm film and for 35-mm " CinemaScope " film, as shown in Fig. 2)

In contrast with " CinemaScope ", the scene is photographed on the film in natural proportions. The shape of the projected picture therefore corresponds to that of the frame (the film mask is 48·5 × 22 mm) and an anamorphic projection lens (as in " CinemaScope ") is not used.

On the wide film there is room for six magnetic sound-tracks, which give well-nigh perfect stereophonic reproduction (a magnetic sound-track can give a higher quality of reproduction than an optical sound-track). These sound-tracks can be seen in Fig. 3, the two wide black bands on the outside of the perforations carrying two tracks each, and the two narrower bands inside the perforations one each. Behind the screen are five groups of loudspeakers, whilst in the auditorium there is a further number of loudspeakers used for special sound effects. Each group is supplied by its corresponding sound-track. It is now not necessary to have the six sound-tracks on a separate synchronously driven film, as is the case with the " Cinerama " system. The greater frame height and the higher frame frequency combined increase the film speed by a factor of more than 1·5 times that with normal film ; as a result, the quality of the sound is improved, and high frequencies can now be better recorded and reproduced.

The special projector used in the " Todd-A.O. " system has been developed by Philips at Eindhoven, where it is now being manufactured. This projector is so constructed that it is suitable not only for the new system but also for normal 35-mm and for 35-mm " CinemaScope " films. The projector (Fig. 4) has an optical sound head (for the optical sound-tracks on 35-mm film) and a magnetic sound head for 35-mm " CinemaScope " film and for 70-mm film. These heads are so arranged that the film can by-pass the heads not in use. The magnetic sound head has a total of ten pick-ups, six of these corresponding to the sound-tracks of 70-mm film, and the other four to the sound-tracks on 35-mm "CinemaScope " film.

The sprockets have four toothed rims; the inner two

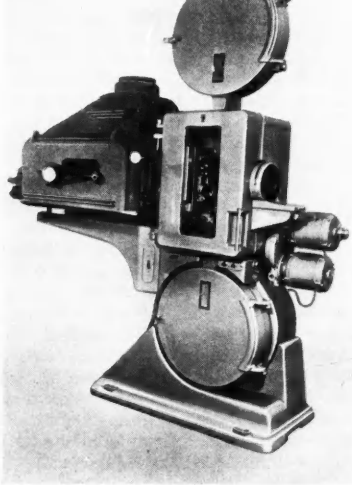


Fig. 4. 70-mm film projector.

are used for transporting 35-mm film, and the outer two for 70-mm film. The film is drawn forward by a 4-slot Maltese-cross mechanism, and the intermittent sprocket must therefore have a periphery equal to 4 times the size of the frame. As already stated, the height of the frame in 70-mm film is 25% more than that of 35-mm film. The periphery, and consequently also the diameter of the intermittent sprocket, must differ by this same factor for the two sizes of film. Hence, the 70-mm film is clear of the sprocket teeth for 35-mm film.

When transferring from one film size to the other, some re-adjustments have to be made; thus, for instance the film guide (which guides the film at the gate) and the pad rollers (which keep the film on the teeth of the sprockets) have to be changed. In addition, the speed of the projector has to be adjusted, and for this purpose the apparatus has two motors, seen on the right of Fig. 4, and a selector switch.

70-mm film has a greater tendency than 35-mm film to buckle in the film gate under the influence of the heat generated by the arc lamp. This would cause the projection to become blurred and to prevent this, the film guide has been slightly curved, giving the film more rigidity at that point.

The projector is fitted with a single-blade rotating shutter, and the two interruptions per frame necessary are achieved by allowing the shutter to make two revolutions in this period. The effective region of the shutter blade is at the outer edge and at a large distance (about 12 cm) from the point of rotation. This blade interrupts the light-beam only 12 mm from the film at a point where the diameter of the beam is small. With these measures shutter losses are reduced to 46%.

The high number of revolutions of the shutter (3600 rpm for 70-mm film) cause the projector to run with more noise than is usual. Also the " flapping " of the wide film is noisier than that of normal film. This is due to the increased width, the greater frame shift, and the higher frame frequency. However, when the projector door is closed, the noise is not sufficient to be disturbing.

JAPAN

A Study of Surface Roughness in Grinding

By K. Sato. (From *The Technology Reports of the Tôhoku University*, Vol. 20, No. 1, 1955, pp. 59–70, 10 illustrations.)

In this paper, an analytical equation is presented for surface roughness in grinding, assuming that the deformation is ideally plastic. From this equation are explained quantitatively the effects of grinding wheels (grain size and wheel grade) and of operating conditions (depth of cut, table feed, and work speed) on surface roughness.

As the grinding operation is based on the process of removal of hard materials by the cutting action of fine abrasive grains, it is important that finished surfaces should be very smooth. The qualitative measurement of scratch depth has been satisfactorily effected, and the factors influencing surface roughness in grinding operations have been studied by a number of investigators, including Opitz[1], Boston[2], and Ono[3].

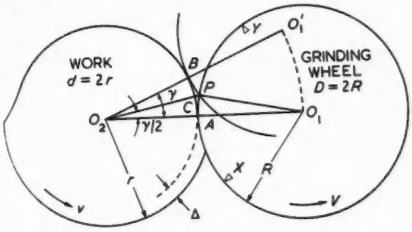


Fig. 1. **Geometrical relations in cylindrical grinding.**

In grinding practice, the contact surface is subjected to severe stress and high temperatures. Moreover, as a result of the random geometry of the cutting points of the grinding wheel, the surface scratches formed are extremely irregular. However, as an ideal case, the following is a consideration of the geometrical profile of the surface cut by uniform and equidistant cutting points in cylindrical grinding :—

At first, the scratch depth h parallel to the direction of grinding is calculated. Fig. 1 shows the geometrical relations in cylindrical grinding, where a cutting point X on the grinding wheel O_1 passes a point A on the workpiece O_2, and the next cutting point Y passes the same point. When the work rotates through an angle γ, while the cutting point travels a distance XY, the scratch depth h is represented by the height CP. If the distance between the successive cutting points XY is denoted by a, angle γ can be expressed by the equation

$$\gamma = \frac{v\,a}{V\,r} \quad .. \quad .. \quad .. \quad (1)$$

where v is the surface speed of the work, V the speed of the grinding wheel, and r the radius of the workpiece.

From the geometrical relation of triangle O_1O_2P, i.e.,

$$O_1P^2 = O_1O_2^2 + O_2P^2 - 2(O_1O_2 \times O_2P)\cos(\gamma/2)$$

the scratch depth $CP = h$ can be represented by r, R, and γ, where R is the radius of the grinding wheel. As h is very small compared with r, h^2 is negligible. As γ is also very small, the following approximation may be written :

$$\cos(\gamma/2) = 1 - \gamma^2/8 + \ldots$$

$$\text{Hence, } h = \frac{1}{8}(r + R)\frac{r}{R}\gamma^2 \quad .. \quad .. \quad .. \quad .. (2)$$

and, substituting for γ from eq. (1).

$$h = \frac{r + R}{8\,rR}\left(\frac{v}{V}\right)^2 a^2 \quad .. \quad .. \quad .. \quad ..(3)$$

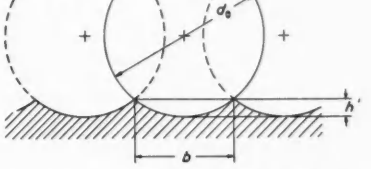


Fig. 2. **Scratch depth perpendicular to the direction of grinding.**

Next, the scratch depth h' perpendicular to the direction of grinding is calculated. Assuming that all the cutting points of the abrasive grains are uniform and spherical, with a constant diameter d_0, and that the surface scratches cut by these points have the same profile, h is expressed, as in Fig. 2, by

$$h = \frac{1}{4}\frac{b^2}{d_0} \quad .. \quad .. \quad (4)$$

where b is the scratch width.

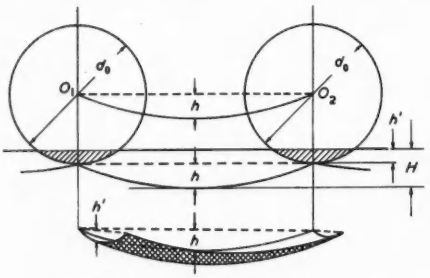


Fig. 3. Model of surface left by spherical cutting edges.

As shown in Fig. 3, the ideal and mean profile of scratches is the surface left by the spherical cutting edge, limited by the height of h. Hence, the maximum roughness H may be expressed as the sum of h and h', so that

$$H = \frac{r+R}{8rR}\left(\frac{v}{V}\right)^2 a^2 + \frac{b^2}{4d_0} \quad .. \quad (5)$$

It has so far been considered that the grinding wheel passes only once over the surface. In practice, of course, the grinding wheel makes several passes. The number of passes C can be represented by

$$C = E/f \quad .. \quad .. \quad (6)$$

where E is the wheel width and f the table feed per revolution of the workpiece.

Assuming that the scratch width is inversely proportional to the number of passes, then the scratch width b' after C passes can be written as $b' = b/C = b(f/E)$. Hence, the analytical equation expressing the mean scratch depth b in cylindrical grinding can be written as

$$H = \frac{r+R}{8rR}\left(\frac{v}{V}\right)^2 a^2 + \frac{b^2}{4d_0}\left(\frac{f}{E}\right)^2 \quad .. \quad .. \quad (7)$$

In surface grinding and internal grinding, the corresponding equations are respectively

$$H_s = \frac{1}{8R}\left(\frac{v}{V}\right)^2 a^2 + \frac{b^2}{4d_0}\left(\frac{f}{E}\right)^2 \quad .. \quad (8)$$

$$H_i = \frac{r-R}{8rR}\left(\frac{v}{V}\right)^2 a^2 = \frac{b^2}{4d_0}\left(\frac{f}{E}\right)^2 \quad (9)$$

From these equations, surface roughness in grinding can be summarized as follows :

(1) With an increase in the distance a of successive cutting points, roughness increases in proportion to a^2.
(2) The effects of wheel speed V and work speed v are that roughness is proportional to the square of the ratio v/V.
(3) Roughness is also proportional to the square of the mean scratch width b, when the wheel makes one pass.
(4) Depth of cut Δ of the wheel has no relation to surface roughness.
(5) With an increase in the table feed f per revolution of the workpiece, roughness increases in proportion to f^2.

Of the factors influencing surface roughness in grinding, v, V and f are determined by operating conditions but the factors a and b are initially defined by grain size and wheel grade, as shown below.

Distance of Successive Cutting Points and Scratch Width

The distance a of the successive cutting points is a valuable factor in the equation of grain depth of cut, and theoretical considerations have been made by many researchers. However, its numerical value has not been determined completely. The author has made several grinding wheels of different grain sizes and grades, and has determined the numerical value of a and b in grinding mild steel on a surface grinder[4].

After some theoretical considerations of the arrangement of abrasive grains in a grinding wheel, the author has measured the grain spacing on the surface of grinding wheels, i.e., the spacing of the cutting points. The results of these measurements are given in Table I. Compared with similar measurements by Shaw[5] and Shiozaki[6], the values in Table I seem to be reasonable.

Table I : Grain Spacings on the Surface of Wheels.

Grain size	30			46			80		
Grit diameter d_0 [mm]	0·70			0·40			0·21		
Wheel grade	H	L	P	H	L	P	H	L	P
Number of cutting points n_1 per cm²	136	278	346	405	500	548	1020	1350	1460
Grain spacing w [mm]	0·85	0·60	0·54	0·50	0·45	0·43	0·31	0·27	0·26

Now, consider the distance a of the successive cutting points. As an ideal case, it is assumed that the cutting points on the face of the grinding wheel are arranged in rows, as shown in Fig. 4, and that they move in the direction from A_{n0} to B, i.e., n_0 cutting-edge points from A_1 to A_{n0} pass over the space AD on the workpiece, leaving n_0 grooves in a width w.

Then, the spacing of the successive cutting points is expressed by

$$a = n_0 w \quad .. \quad .. \quad .. \quad .. \quad .. \quad (10)$$

As $n_0 = w/b$, where b is the mean scratch width, n_0 may be determined. Representative values are listed in Table II.

Table II : Spacings between Successive Cutting Points.

Grain size	30			46			80		
Grit diameter d_0 [mm]	0·70			0·40			0·21		
Wheel grade	H	L	P	H	L	P	H	L	P
Grain spacing w on wheel face [mm]	0·85	0·60	0·54	0·50	0·45	0·43	0·31	0·27	0·26
Mean scratch width b [μ]	36	31	26	26	22	20	13	11	11
Number of grooves n_0 in w	23·8	19·2	21·0	19·5	20·7	21·5	24·8	23·2	23·7
Mean value of n_0		21·3			20·6			23·9	
Spacing of successive cutting points a [mm]	18·1	12·8	11·5	10·3	9·3	8·9	7·4	6·5	6·2

In normal grinding wheels, the spacing a of the successive cutting points is about 10 mm, as shown in Fig. 5, and its value seems to be proportional to the square root of the grit diameter d_0 of the wheel. The values of the chip thickness computed from these data, derived from the equation of grain depth of cut

$$g = \frac{v}{V} a \sqrt{\frac{r+R}{rR}} \sqrt{2\Delta} \quad .. \quad (11)$$

are of the order of a few microns.

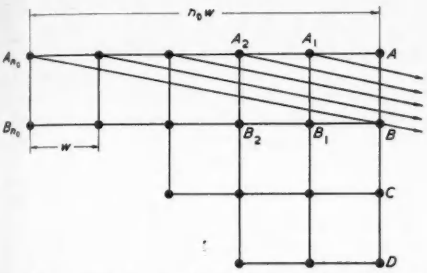


Fig. 4. **Diagrammatic representation of the spacing of successive cutting points.**

The Effect of Grain Size on Surface Roughness

In practice, grinding wheels of a grain size of about 30 are used for rough-grinding of large pieces ; for finish-grinding, grain sizes of from 60 to 80 are used, while for special fine finishing grain sizes up to 200 may be used. Thus, it is assumed that the finer the grain size the finer is the surface finish. The quantitative relation between grain size and surface finish may be derived from eq. (7).

As already mentioned, the mean scratch width $b = w/n_0$. Also, w is experimentally related to the grit diameter d_0, as $w = kd_0$, so that eq. (7) may be written

$$H = \frac{r + R}{8rR}\left(\frac{v}{V}\right)^2 a^2 = \frac{1}{4}\left(\frac{k}{n_0}\right)^2\left(\frac{f}{E}\right)^2 d_0 \quad .. \qquad (12)$$

In this equation, the factors affected by grain size are a, k, n_0, and d_0. As already mentioned, a is proportional to the square root of d_0, and k/n_0 has no systematic relation to grain size, though the wheel grade has a significant relation to a. Accordingly, it is concluded that surface roughness H is directly proportional to grit diameter d_0.

For example, measurements of surface roughness by Boston[2] have shown that the values of surface roughness obtained with wheels having a grain size coarser than 80 are, despite considerable scatter in the results, proportional to the grit diameter. However, in the case of finer grain sizes, the values of surface roughness obtained are higher than the proportional values. Experimental data by the author on a surface grinder did not show appreciable differences in wheels of several grain sizes, where the grinding conditions were $V = 1800$ m/min, $v = 5{\cdot}5$ m/min, $R = 90$ mm, $\Delta = 0{\cdot}05$ mm, and $f = 2$ mm per stroke.

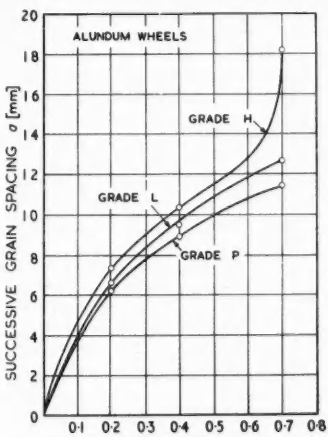


Fig. 5. **Relation between spacing of successive grains and grit diameter.**

The theoretical values of surface roughness computed from the grinding conditions noted above are unexpectedly small. This leads to the conclusion that, in practice, the profile of the cutting edges (mainly affected by the cleavability of the grit) and the vibration of the grinding machine may have an adverse effect on surface roughness.

Moreover, the computed values show that the roughness h in a direction parallel to the cut is very small, compared with the roughness h' perpendicular to the cut, and it is concluded that the table feed f or the surface speed v of the workpiece may be changed to a value where h becomes comparable with h'.

The Effect of Wheel Grade on Surface Roughness

In eq. (12), which expresses surface roughness, the factors affected by the wheel grade are a and k/n_0. Now, the harder the wheel grade, the smaller will be the values of both a and k/n_0. Accordingly, surface roughness H is generally reduced when the wheel grade is harder.

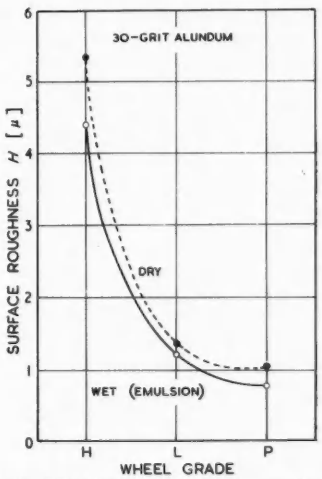


Fig. 6. **Effect of wheel grade on surface roughness.**

Experimental data by the author, as shown in Fig. 6, have confirmed the conclusion made above, while a number of investigators, including Ono[3], have also verified this conclusion experimentally.

In practice, the harder is the wheel grade, the more likely is the ground surface to burn and to result in a badly deformed layer. Hence, for good finishing, it is not practical to use a hard-grade wheel. On the contrary, it is desirable to use as soft a grade of grinding wheel as possible ; in addition, machine vibration should be prevented and the grit selected should be of optimum cleavability.

The Effect of Depth of Cut on Surface Roughness

From eq. (7) it is clear that the depth of cut Δ of the wheel does not exercise a direct influence on surface roughness H. However, as shown in eq. (11), the grain depth of cut increases in proportion to the square root of Δ. Consequently, the force acting on each grit will

increase with increased Δ, and the profile of the cutting edge will be more irregular, because of the severity of the cleavage of grits. Furthermore, machine vibration will increase with increased Δ. As these secondary phenomena may affect surface roughness, it is common practice in finish-grinding to take a small depth of cut.

Experimental data by the author have shown that surface roughness remains unchanged when grinding depth increases from 0·02 to 0·06 mm in the surface grinding of cast iron and hardened steel. In the grinding of mild steel, however, some increase in surface roughness, mainly caused by molten metal adhering to the cutting edge, was noted.

The Effect of Surface Speed of the Workpiece and Table Feed on Surface Roughness

During grinding, as the surface speed of the workpiece and the table feed are directly related to operating time and hence to labour costs, speeds should be as high as possible. In eq. (12) the surface speed v of the workpiece is related to the maximum roughness H in the first term only. On the other hand, f, which is the longitudinal table feed per revolution of the workpiece in cylindrical grinding, or the transverse table feed per stroke in surface grinding, is related to H in the second term only. In practice, it seems to be desirable to select operating conditions in such a way that the first term in eq. (12) is comparable with the second term.

Computed values of surface roughness show that, as roughness h' perpendicular to a scratch is about 100 to 400 times greater than roughness h parallel to a scratch, the values of h may be increased from 10 to 20 times, while the values of h' may be reduced to between 5 and 10% of the computed values. This means that v may be increased by from 3 to 5 times its amount under test conditions, i.e., it may reach about 20 m/min—a value which agrees with the standard value for surface speed of the workpiece in normal grinding, given by the conventional formula $v/V = 0{\cdot}01$.

For the same reason, when considering f/E, it is desirable that the table feed f should be one-third or one-fifth the wheel width E. This also seems to be normal practice.

Experimental data in connection with cylindrical grinding, obtained by the author on a universal grinder, have shown qualitatively good agreement with the theory, though quantitatively the values computed from eq. (12) were very small, being only about 2% of the experimental values. The differences seem to be mainly attributable to the fact that, while the values of the successive cutting points a and of scratch width b are mean values, the measured data of surface roughness are the values of maximum roughness. From the distribution of the measured data of a and b, the maximum values are assumed to be about twice as large as the mean values and, as their effects are influenced by the squared terms in eq. (12), values four times as large as the computed values can be expected.

Another reason for the differences noted may be the value of the diameter of the cutting edge d_0. In the calculation, d_0 is assumed to be the grit diameter, but in practice the cutting-edge diameter may be changed by cleavage. As experiments seem to indicate that its value may be from one-third to one-fourth the grit diameter, the computed values may be about 10% of the actual values. If, in addition, a few microns are allowed for machine vibration, the difference between the actual and computed roughness seems to be explained.

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Conveyor-Belt System of Passenger Transportation

Based on continuous conveyor belts operating at different speeds, a new American method of relieving congestion in crowded areas has been devised for installation in large cities. The New York scheme, which is designed to replace the present shuttle service between Grand Central Station and Times Square (a distance of about 2200 ft), will be capable of handling 36,000 passengers per hour, as against the present 23,000. Furthermore, it has the advantage of requiring neither drivers nor guards.

In this new project, all passengers on arrival at the station proceed to one platform, where a moving belt, 60 ft in length, called the " Speedwalk ", is running at a constant speed of 1½ mph. Alongside this belt, where the tracks of the underground railway would normally run, is another conveyor belt, moving at the same speed, on which 19 separate passenger cars arrive every minute. Once he is on the Speedwalk, all that the passenger has to do is to step into the car, the doors of which open and close automatically; the car then rolls 74 ft over a bank of accelerator wheels which quickly step up the speed of the conveyor from 1½ to 15 mph. Spacing between the cars is increased as they are placed on this main-line conveyor.

When the terminus is reached, the cars are slowed down in another 74 ft run, this time over a bank of decelerator wheels, and are delivered bumper to bumper to an offloading Speedwalk, also moving at 1½ mph. Having arrived at their destination and emptied, the cars then describe an arc on banks of powered wheels (equipped with pneumatic tyres) and pick up their passengers on the other side for the return trip, after which the whole process is repeated. The journey will take two minutes each way.

As stated above, the maximum speed of the cars on the main-line conveyor is 15 mph. This, however, applies only to the New York scheme and is not in any way indicative of the maximum speed possible with the conveyor-belt system. Actually, it is stated that similar schemes, operating over considerably greater distances than that involved in the New York project, can be devised for greater or lower speeds, according to requirements.

A demonstration model, 15 ft in length, indicating the salient characteristics of the conveyor-belt system of passenger transportation, is being shown at the Mechanical Handling Exhibition in London.

British Industrial Developments

Pulse-Supercharging of Two-Stroke Diesel Engine

When the Kahlenberg E.6 engine, a six-cylinder, two-stroke, uniflow, direct-reversing marine diesel, was being developed by the Kahlenberg Bros. Company, of Wisconsin, U.S.A., as a mechanically scavenged engine with a rating of 512 bhp and 75 psi bmep at 325 rpm, D. Napier & Son, Ltd., of London, were consulted with regard to the possibility of improving the rating to 700 bhp and 103 psi bmep at the same engine speed, by supercharging the engine with one of their turbo-chargers. It was also hoped that turbocharging would eliminate the need for a mechanically driven scavenge-pump, thereby improving the fuel economy of the engine.

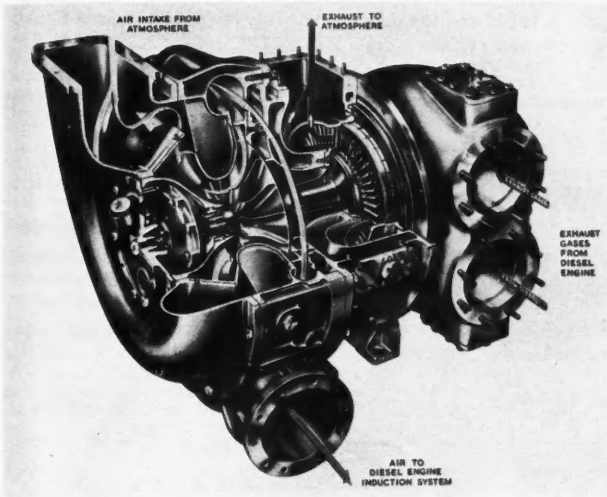

AIR INTAKE FROM ATMOSPHERE
EXHAUST TO ATMOSPHERE
EXHAUST GASES FROM DIESEL ENGINE
AIR TO DIESEL ENGINE INDUCTION SYSTEM

Fig. 1.

It was decided that the Napier M.S.200 turboblower, shown in section in Fig. 1, could be matched to the engine to provide the desired power increase and, if operated on the " pulse " system, could combine the functions of supercharging and scavenging. The pulse system uses the exhaust gases at practically the pressure and temperature at which they are discharged from the cylinders to drive the turbine. The fall in exhaust-manifold pressure after each pulse permits sufficient scavenge air to pass through the cylinder to ensure efficient evacuation of the exhaust gases and cooling of the piston and combustion space.

The turbocharging system was applied to the engine, as shown in Fig. 2, the turboblower being installed on the engine, close to the exhaust manifold and directly above the air inlet manifold. Ducting was arranged to carry the compressed air from the compressor outlet casing to a charge cooler, which would deliver directly into the inlet manifold. The compressor inlet casing of the blower was equipped with a combined air filter/silencer, making it possible to draw air directly from the engine-room, instead of ducting it from outside.

Initial tests of the turbocharged E.6 engine were highly satisfactory, quick and easy starting being obtained without the assistance of an auxiliary blower. Furthermore, performance was smooth and good combustion characteristics were obtained throughout the speed and load range of the engine. The advantageous effect of turbocharging on specific fuel consumption was well established. There is an appreciable reduction over the whole bmep-range, while from 80 bmep, where the fuel-consumption curve of the mechanically scavenged engine begins to climb, the improvement is even more pronounced. At 100 bmep the specific fuel-consumption curve is still flat, giving promise of even greater economy at higher bmep-values, and indicating that the initial target for the turbocharged engine was conservative. Furthermore, there are indications that the scavenge air pressure increases with duty—a characteristic of turbo-charged engines.

As a result of the successful application of turbo-charging to the E.6 engine, Kahlenberg are to standardize Napier turboblowers on their engines at the 103-psi bmep rating, and their close association is to be continued in the development of the engine to higher ratings and speeds.

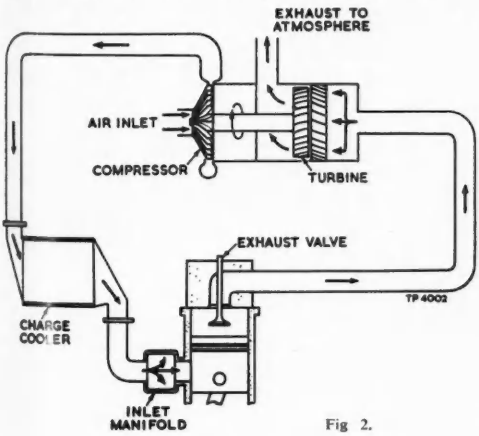
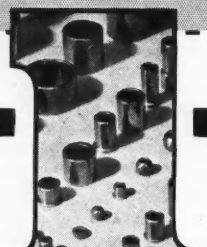


Fig 2.

Lightweight Flywheel-type Alternators

An entirely new type of lightweight alternator, which takes the place of the engine flywheel in a diesel generating set, and which is provided with a new voltage control system called " Rectiflex " (a contraction of " Rectified Excitation "), has been developed by Brush Electrical Engineering Co. Ltd., of Loughborough. An important feature of the design is that the yoke (field system) is made to couple directly to the flange end of the engine crankshaft and rotates about the outside of the armature, which is stationary. The rotating yoke has a considerable flywheel effect and, by replacing the conventional flywheel, reduces weight, overall length of the set, and cost. The stationary armature is of simple construction and has a much lower iron loss than an armature of

Lubricant-retaining bearings matched to each application



COMPO *POROUS BRONZE BEARINGS*

Made from pure powdered metals Compo Bearings are die-pressed to very close tolerances, making additional machining unnecessary. The porous structure of the metal is impregnated with oil and provides its own storage. Oil is fed to the shaft by capillary attraction, regulated according to speed and temperature. A wide range of standard sizes is available for delivery from stock.

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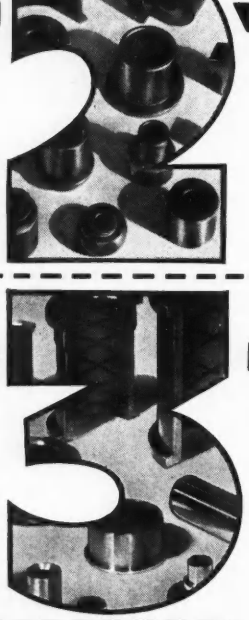

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Bound Brook Graphited Bearings are made of cast bronze, inlaid with a special hard graphite lubricant in grooves or holes to suit the application. Particularly suitable for temperatures up to 600° F. or for immersion in liquids, where ordinary oil or grease lubrication is liable to fail. Continuous lubrication is maintained whether the motion is revolving, oscillatory or reciprocating.

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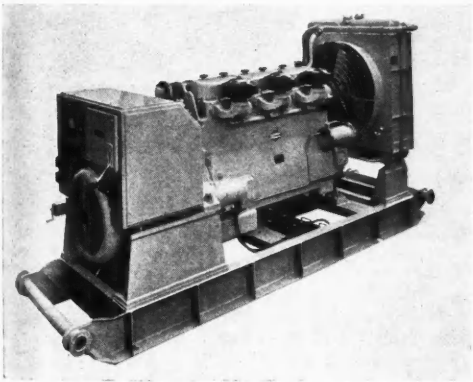
normal design. An additional advantage is the straightforward ventilating system, in which large inlet and outlet areas can be used. Furthermore, a large rotating mass is available to dissipate heat.

The field coils are wire-wound and bent to shape before impregnation and, as they are bent to conform to the curvature of the yoke, the coils take up the minimum radial depth, so that the overall diameter of the yoke is small. The passages between the coils are narrow, and the consequent higher speed of air flow ensures excellent cooling. Silicone insulation has been used throughout, and, at the rated output under normal ambient conditions, the "hot-spot" temperatures are sufficiently below 180°C, the I.E.C. recommended safe temperature for this class of insulation. The machines are now available in 100-kW and 150-kW sizes. A 250-kW set is now being developed and the possibility of building even larger sizes is not excluded. The illustration shows a flywheel alternator with Rectiflex control, driven by a Petter-McLaren six-cylinder diesel engine developing 150 bhp at 1500 rpm, for 100 kW and 50 cps.

The main advantage of the Rectiflex system of excitation and voltage control is that it is completely static. The main alternator field is supplied from a rectifier, the input side of which is connected across the alternator output terminals through a transductor, the saturating winding of which is supplied by a magnetic amplifier whose input is derived from a voltage detector unit, also fed from the alternator terminals. As a result, any variation in alternator terminal voltage is fed to the detector, amplified, and then applied to the saturating winding of the transductor, thus varying its reactance and, in turn, the field current of the alternator.

Owing to the relatively high forward resistance of the main rectifiers, it is necessary to boost the residual voltage of the alternator, to ensure that voltage build-up takes place. This is effected by providing an auxiliary winding on the main transductor, which converts it into a transformer. This winding is energized via a starting relay, and cut out of the circuit when the voltage reaches such a value as to ensure satisfactory build-up. The steady-state characteristics of the system are extremely good and, although a nominal regulation of only $\pm 2\frac{1}{2}\%$ is guaranteed, a much closer regulation than this is inherently possible, owing to the very large amplification of the system.

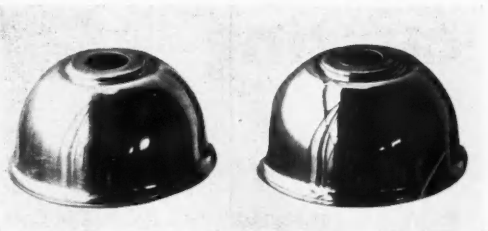


Parallel running is possible with both similar and dissimilar sets, provided the latter have reasonably stable drooping voltage load characteristics. Generally, a 3% voltage droop from no-load to full-load is required, but this can be improved upon in many cases. A further advantage of the Rectiflex system is that, in the event of failure of any of the components other than the main rectifiers, hand control can be arranged.

Bright Nickel-Plating Process

With the increasing use of automatic plating equipment, bright nickel plating has become an economic necessity. Most of the processes in general use, however, have certain limitations. The deposits produced do not always give the length of service reasonably expected, and the low ductility of some of the commercial deposits results in premature cracking and subsequent corrosion. To meet the demand for a bright nickel combining good mechanical properties with effective surface levelling and high brilliance, an improved bright nickel process—"Nimax"—has been introduced by W. Canning & Co. Ltd., of Birmingham. The solution is simple to maintain, requiring the use of a single addition agent ("Sylax") for the maintenance of both brightening and levelling properties. The process is economical in operation and suitable for iron, steel, brass, copper, and other common metals, including zinc-base diecast alloys (after copper plating).

"Nimax" has an exceptionally good throw and excellent covering power, with a wide bright-plating range. The excellent levelling and scratch-filling properties of the deposit permit initial polishing of the articles to be reduced to a minimum. In addition, the deposit is free from surface passivity, permitting direct chromium plating without the necessity for surface activation.



The "Nimax" nickel process under prolonged tests has produced deposits having a ductility consistently over 12% elongation, combined with a comparatively low internal stress. This high ductility is especially important where components have to be further fabricated after plating, and the good mechanical properties of the deposit result in increased service life for components of all types. "Nimax" bright nickel-plating solution is used in rub berlined bright nickel-plating equipment and is operated at a temperature of 120 to 130°F at a current density of 36 to 60 A/sq ft. Its comparatively high operating pH value of 4 to 4·5 minimizes dissolution of any exposed unplated metal and thus reduces to a minimum any subsequent metallic contamination of the solution. The illustration shows (left) typical bright nickel on a 180-emery finish, and (right) a "Nimax" bright nickel deposit of similar thickness on a 180-emery finish.

Metallic Vibration Eliminator

Claimed to have the highest fatigue resistance of any vibration eliminator in the world and, when used with rigid piping as a composite assembly, to provide the lightest form of metallic flexible piping with a minimum of flow resistance, the first standard seamless metallic flexible vibration eliminator for general engineering requirements to be manufactured in Great Britain has been developed by the Compoflex Co. Ltd., of London, S.W.1.

These eliminators will be available in copper alloy for use in situations where temperatures up to 250°C and pressures up to 450 psi are experienced, but they will also be made in Monel metal or in stainless steel, suitable for temperatures up to 400°C and pressures up to 1000 psi. Special assemblies can be produced for even higher temperatures and pressures.

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The eliminators, which are of seamless helical tubing, generally covered with a bronze braiding, will be available in bore sizes ranging from ¼ to 2 in. Two standard types of fittings have been developed, i.e., a sleeve at both ends, into which standard sizes of rigid piping can be brazed, or a sleeve at one end and a suitable union nut and nipple at the other. Alternative end connections, including fire-resistant connections for the higher specified temperatures, can be manufactured for specialized requirements.

These vibration eliminators are designed for installations which have pipes prone to misalignment or which are exposed to vibration, inasmuch as they are sufficiently flexible to absorb vibration and to relieve stresses arising from temperature changes in pipe-lines. They take the place of coiled piping, sliding joints, etc., and also of rigid connectors made up on site. It is claimed that these eliminators will operate efficiently on gas- and air-compressor delivery lines, refrigeration-compressor lines, steam lines in industrial and marine boiler plants, fuel-oil and air systems of road vehicles, fuel and gas lines in aircraft, and liquid and gas lines in chemical plants.

Self-Adhesive Tape for Strapping or Sealing Cases

Designated "Permacel Super Strapping Tape", a new product for strapping or sealing wooden cases, cardboard cartons, etc., is announced by Johnson & Johnson (Gt. Britain) Ltd. The tape embodies a P.V.C. backing with extra-strong reinforcing strands deep-coated with adhesive, and has a high tensile strength (200 lb breaking strain for the 1-in. width).

The new tape has been introduced to supersede steel wire or strapping, and its uses include sealing and protecting cartons, heavy handling operations, securing goods during palletization, and bundling timber, rods, and wires. By virtue of the fact that it is not only supple but also gives continuous support, without biting into the edges of cartons, it ensures longer package life and more efficient protection of contents. Furthermore, it is waterproof and is unaffected by climatic changes, ranging from extreme cold to tropical heat. A dispenser, suitable for all self-adhesive tapes up to 2 in. in width, has also been developed.

Miniature Barium Titanate Accelerometers and Strain Gauges for Vibration Testing

Two new devices, the first of their kind to be made available on a large scale in Great Britain, and with many advantages over older methods of vibration measurement and detection, have been developed by the General Electric Co. Ltd., of London, W.C.2. These devices—miniature barium titanate accelerometers and strain gauges—are inexpensive, reliable, and simple to operate, and their greatly reduced size enables them to be used in a variety of applications where it would be impossible to accommodate more bulky equipment. Furthermore, they are extremely sensitive and will work efficiently over a relatively wide range of temperatures and vibration frequencies.

The accelerometer consists basically of a circular disc of barium titanate, about ⅛ in. thick and ⅜ in. in diameter, which is silvered on both sides and sandwiched between two pieces of brass, one piece forming the base and terminated by a stud for fixing purposes, while the other acts as an inertia weight. The accelerometer is only ¾ in. in length and can easily be attached by its stud to any piece of equipment whose vibration characteristics are to be studied. Though simply and robustly constructed, the unscreened version—Fig. 1 (left)—weighs only 11 grams, and the screened version—Fig. 1 (right)—18 grams, so that the loading effects on the apparatus under test are minimized. The response of the instrument to accelerations up to 1000 *g* is linear, and its charge sensitivity gives a voltage output of about 20 mV/*g* with conventional circuitry. It will detect and record frequencies in the range between 20 c/s and 20 kc/s, and between 40 c/s and 10 kc/s it is accurate to within ± 10%. An important design feature is the construction of the base, which is reduced in thickness just above the mounting stud. This is most effective in reducing spurious signals due to strains in the object under test, and also reduces the effect of transverse accelerations. Operation of the accelerometer is effective between — 50°C and + 100°C, voltage sensitivity varying with temperature to the extent of only 0·15%/°C.

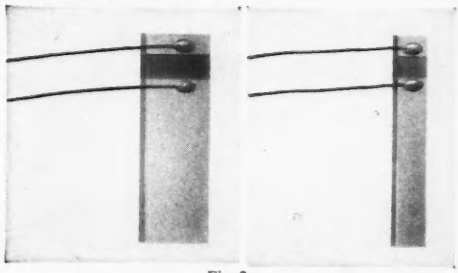


Fig. 2.

The vibration strain gauge (Fig. 2) consists of a thin bar of polarized barium titanate with silver electrodes on the two major faces. The electrode on the lower face is extended around one edge onto a small part of the upper face, and the leads are soldered to the electrodes on the upper face. The underside of the gauge is attached to the object to be tested and, when the latter vibrates, the alternating strains in the plane of the gauge produce an alternating charge on the electrodes.

Unlike the accelerometers, these strain gauges are not supplied calibrated, as they are intended primarily for the determination of the various frequencies at which resonant vibrations occur in mechanical structures and their approximate relative strengths.

The strain gauges are made in two standard sizes, i.e., ¾ × ¼ × 0·035 in., and ⅜ × ⅛ × 0·035 in. respectively. They will operate in the range between 20 c/s and 50 kc/s, sensitivity being of the order of 0·1-V output for an alternating displacement of one part in one million. Effective operation is obtained between — 50°C and + 100°C. An important feature of these gauges, not possessed by other types of gauge, is that they can be used either to detect vibrations or to excite them by the reverse process of applying an alternating voltage to the crystal, thereby considerably increasing the scope of vibration measurements which can be made on mechanical structures.

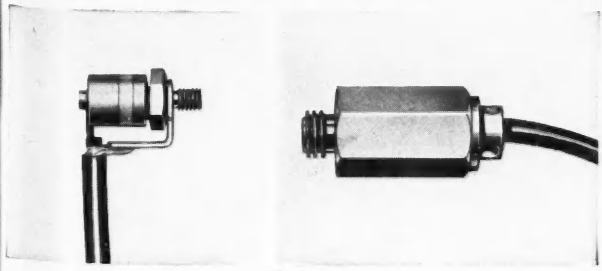
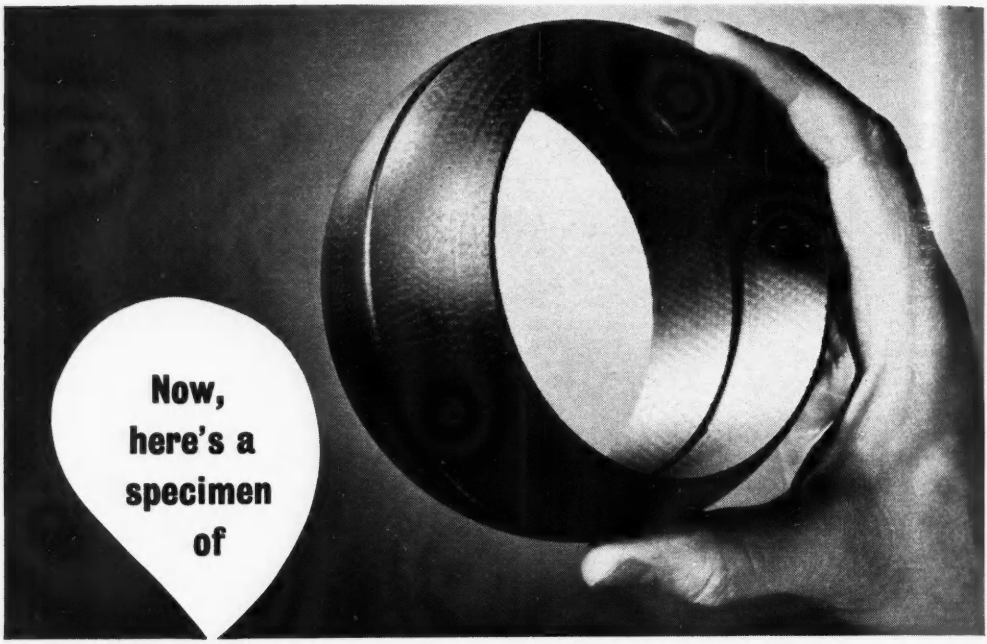


Fig. 1.



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CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

ACOUSTICS

A Redetermination of the Equal-Loudness Relations for Pure Tones.

By D. W. Robinson and R. S. Dadson. (From *British Journal of Applied Physics, London*, Vol. 7, No. 5, May 1956, pp. 166–181, 14 illustrations.)

In the study of many aspects of subjective acoustics, and especially in the study of noise, the concept of the " loudness " of a sound is of fundamental importance. It is, of course, clear that loudness is not the only subjective attribute of a complex sound which may be of concern, though it is frequently the primary factor.

Sounds may be analysed in various ways, but for most purposes analysis into a frequency spectrum, either of individual components or a distribution in terms of frequency bands, is the most convenient. It thus comes about that the loudness relations for pure tones of different frequencies and, as an extension of this, the corresponding relations for distributed sound in particular frequency bands are not only of great interest in themselves but are of basic importance in many applications. Such diverse problems as the study of the behaviour of the ear to complex sounds, and the procedure by which it arrives at a characteristic loudness sensation, the selection of frequency weighting networks for objective noise meters, and the development of methods for computing the loudness levels of complex sounds from objectively measured spectrum analyses, all rest at some stage or other on a knowledge of the equal-loudness relations for pure tones or other simple sounds. The relations are also involved in many aspects of the communication and reproduction of speech and other sounds.

Described in this paper is a new determination of the equal-loudness relations for pure tones in free-field conditions, carried out at the National Physical Laboratory as a result of requests from organizations interested in various aspects of the acoustics of hearing. In this work use was made of a large team of otologically normal persons, while new techniques were introduced, enabling reliable measurements to be made over a wider intensity range than has hitherto been possible. The new results cover a range of frequency of from 25 to 15,000 cps, and of sound-pressure level up to about 130 db relative to 0·0002 dyn/cm². The data show a greater degree of regularity than former results, and allow the equivalent loudness of a pure tone of any frequency to be expressed by formulae quadratic in the sound-pressure level, the coefficients varying smoothly with frequency. The results include a new determination of the normal threshold of hearing in free field, which is highly consistent with the equal-loudness contours. At frequencies above 1000 cps account needs to be taken of variations caused by the age of the observers, these variations becoming of particular importance at the upper end of the frequency range. Thus, at 15,000 cps, the equal-loudness relations suggest a kind of saturation effect in the process of audition. An effect analogous with bilateral recruitment also seems to occur at high frequencies in observers of the higher age groups.

The new results have indicated the causes of some of the discordant features in earlier determinations, and it is hoped that the work will facilitate agreement on a standard set of equal-loudness contours. On account of its relevance to noise measurement, some extension to equal-loudness relations for bands of noise is being undertaken.

FLOW OF FLUIDS

Special Devices for Measuring Discharge at Low Reynolds Numbers.

By A. L. Jorissen. (From *Transactions of the ASME, U.S.A.*, Vol. 78, No. 2, February 1956, pp. 365–368, 5 illustrations.)

The utilization of constant-area differential types of fluid meters is in many cases limited to conditions for which the coefficient of discharge may be considered as practically independent of Reynolds number. This is true for orifices, nozzles, and venturi tubes. Under a certain value of Reynolds number, the coefficient of discharge exhibits a variable trend. The discharge may then only be computed by a method of successive approximations. Furthermore, experimental evidence shows that the accuracy of the device is generally lowered.

Since the accurate measurement of discharge at low Reynolds numbers is important in many cases (e.g., oils, various solutions, gases containing a large amount of hydrogen, hot gases, and gases at low pressure), the twofold problem has arisen of investigating the behaviour of standard devices at low Reynolds numbers and of studying new types of devices, more suitable for the measurement of fluid flow to Reynolds numbers as low as possible. By " low Reynolds numbers " is meant those flow conditions for which the flow Reynolds number is inferior to the lower limit to which the coefficient of discharge is maintained constant.

Numerous investigators have attempted to develop a new type of differential fluid meter in which, by compensation of the effects of contraction and friction, a constant value of the coefficient of discharge can be maintained at low Reynolds numbers. As a result of the author's study of this problem, it is concluded that a number of devices offer distinct possibilities of maintaining a constant coefficient of discharge down to low values of Reynolds number. Particularly noteworthy, in the author's opinion, are the quadrant-edge orifice and the cylindrical nozzle, with or without conical diffuser. For both, experimental evidence is available as proof of their satisfactory operation.

GAS TURBINES

A Standard Gas Turbine to Burn a Variety of Fuels.

By G. B. R. Feilden, J. D. Thorn, and M. J. Kemper. (From a paper presented at *The Institution of Mechanical Engineers, London*, April 6, 1956, 19 pages, 14 illustrations.)

In this paper two aspects of gas-turbine design and operation are dealt with. In the first of these an account is given of the development of special types of " kinematic " construction suitable for accommodating the very large temperature changes encountered when a gas turbine is started and put on load rapidly. Examples are given of the application of this type of construction to representative components of a 750–1000 kW gas turbine. In this connection, the production version of the gas turbine was conceived from the outset with a view to batch production and its application to a wide variety of duties. One of the advantages of electing to build a machine of relatively low power has been that intensive development of individual components has been justified during the design stage.

Secondly, a description is given of the development of combustion chambers to burn fuels ranging from natural gas and gas oil to residual fuels, coal-tar fuel, and peat.

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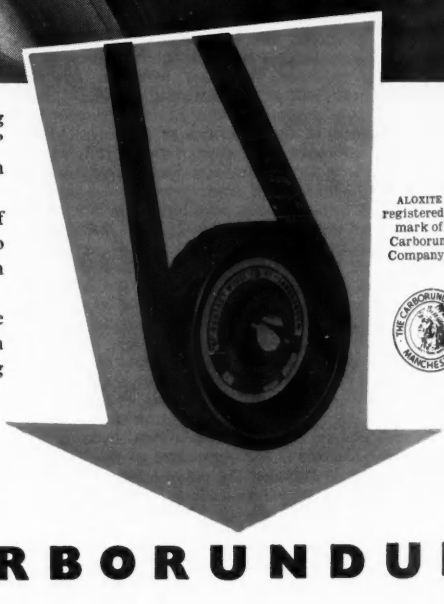

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A range of chambers to burn these fuels has been designed to fit interchangeably on the basic components of the standard turbine. A detailed description is given of the development of a combustion chamber of elbow type which takes advantage of the fact that a number of changes of direction through 90 deg. or more are necessary in the ducting of nearly all industrial gas turbines. Development of this chamber is described from early atmospheric test models to the final pressurized combustion chambers which have been fitted to production gas turbines. With only slight adjustments, this type of chamber has shown itself capable of burning hydrocarbon fuels, ranging from natural gas to residual fuel oils, and a modified form of chamber has also successfully burnt gases of low calorific value.

It is concluded that the elbow chamber has in practice maintained its original promise of mechanical simplicity, accessibility, and economy, whilst proving itself suitable for a wide range of different fuels. It has also been found to be well suited to repeated production without alteration of settings or without calling for techniques which could be applied economically only to mass-production quantities.

MATERIALS TESTING

Tension and Torsion Properties of Some Metals under Repeated Dynamic Loading (Impact).

By D. B. C. TAYLOR and A. Z. TADROS. (From an advance copy of a paper submitted to *The Institution of Mechanical Engineers, London*, April 1956, 15 pages, 11 illustrations.)

IT is now a well-established fact that some metals under rapid straining offer a resistance to deformation which is in excess of the statically measured value. Analyses of this phenomenon, based on the dislocation theory of crystal deformation, have recently been made with a certain degree of success, but the difficulty of such work still lies in attempting to relate the observed dynamic behaviour of a polycrystailine metal to the established single-crystal dislocation concepts.

On the other hand, the behaviour of metals under static loads and the effect of alloying elements and heat treatment on static properties is much more fully understood, though for the actual assessment of the strength of a material under such loading it is still necessary to depend on the normal types of laboratory strength tests. This would also seem to be true of dynamic properties, where, despite any possible future advances in knowledge of the exact mechanism of this dynamic effect in metals and of the factors influencing it, investigators will still be dependent on the results of dynamic straining tests for the quantitative measurement of dynamic strength.

For this reason, therefore, the greater proportion of research work in this field has consisted mainly of the measurement of the quantitative dynamic strength under various types of dynamic straining. In this connection, it would appear that the development of simple and reliable machines for the study of the dynamic behaviour of metals under repeated impulsive loading in both tension and torsion is of value for both practical and theoretical investigations, and it was with this in mind that two such machines were constructed in the Mechanical Engineering Department of Nottingham University. This paper comprises a description of these machines, together with an account of the first series of tests carried out.

The new machines are of the " falling-weight " type, the yield stress (or yield torque) being measured electronically and the total extension (or twist) during a particular loading cycle being limited to any desired value. A preliminary series of tests in both dynamic tension and dynamic torsion, using solid cylindrical bar specimens, $\frac{3}{8}$ in. in diameter, was carried out on a medium-carbon steel, a mild steel, a silico-manganese spring steel, and two aluminium alloys. For tension, the average time from zero stress to the dynamic yield stress was in the range between 0·18 and 1·00 millisec and, for torsion, 0·65 and 2·67 millisec from zero torque to the dynamic yield torque.

In straining specimens to fracture under such repeated dynamic loading, the yield point was found to vary in a manner similar to that for static loading, though all dynamic yield points showed a progressive increase in value with a reduction in loading time. For equal loading times, a greater percentage increase in the yield-point value was noted for the medium-carbon steel and the mild steel under dynamic torsion, as compared with dynamic tension, thus indicating a migration of the criterion of failure away from the Mises-Hencky theory towards the theory of maximum principal stress.

ROLLING MILLS

Rigidity and Spring in Rolling Mills.

By G. WALLQUIST and K. GEDIN. (From *Jernkontorets Annaler, Sweden*, Vol. 140, No. 3, 1956, pp. 155–188, 31 illustrations.)

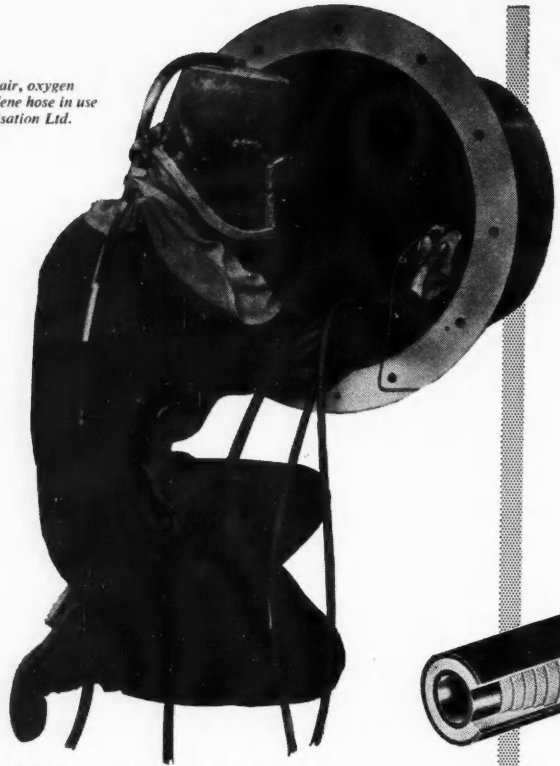
DURING rolling, the gap between the rolls increases, as a result of the roll pressure applied. This so-called spring is composed of lash in bearings, screw-downs, etc., and of elastic extension, and the larger the spring in a mill stand, the more will the dimensions of the rolled product be influenced by variations in roll pressure. The more rigid the stand, the lower will be the elastic extension, and consequently the smaller the amount of spring obtained. The aim of the investigation described in this paper was to study these relationships and, in this connection, to compare older and more modern stands, especially in the case of so-called prestressed mill stands, where a stress had been imparted in the unloaded condition.

The authors used the concepts of total spring [mm], specific spring, i.e., total spring minus lash [mm/ton roll pressure], and spring coefficient [mm/ton variation in roll pressure]. Eleven stands were studied, of which five were of medium size and six were small. Roll pressure was measured with wire strain gauges, which were either applied in special devices for indication and registration of the roll pressure or directly located on one of the structural elements of the stand. Mill spring at the different roll pressures was determined with the aid of small testpieces of lead, which passed between the rolls before and during rolling. Attempts were made both to measure directly and to calculate the different elements of total spring, such as lash and elastic deformation, in different parts of the stand.

The results obtained show that the roll pressure in its relation to mill spring consists of three successively applied ranges, one of very short duration when the lash is removed and thick oil films are contracted, another when the contact surfaces are further compressed and the different parts of the stand start to deform, and the third with only elastic deformation of these parts.

For the five larger stands, with roll diameters from 420 to 622 mm, lash varied from negligible amounts to about 0·75 mm. Total spring was more than 3 mm in the older stands, but only about half this amount in stands of modern design. Exclusive of roll bending, which is influenced by roll dimensions, the corresponding figures for the spring coefficient were 0·011 and 0·005 mm. For the six small stands, with roll diameters from 281 to 380 mm, lash varied from very low values up to 0·10 mm, total spring was 0·90 mm in the oldest stand and about 0·30 mm in the modern stands, and spring coefficient, exclusive of roll bending, varied from about 0·023 to about 0·005 mm per ton.

In general, the modern stands with their heavier dimensions and more suitable design, as well as with the prestressing applied, show considerably increased rigidity and lower spring, resulting in smaller variations in the rolled product. The authors suggest means for improvement of the different types of stands investigated.



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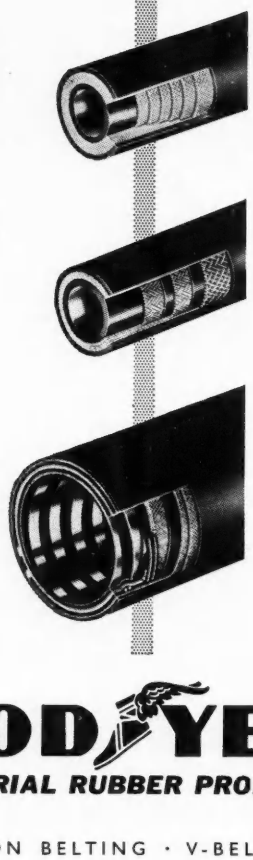

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This type of Goodyear hose has layers of rubberised cotton fabric wound over a smoothbore tube of high grade compounds and protected on the outside with a tough rubber covering. Made in 60′ lengths.

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Braided Cord Hose embodies strong cord layers braided over a lining of high grade compounds and with a smooth, uniform bore. Made with one, two, or three braids as operating conditions demand. A heavy cover of tough rubber provides exceptional resistance to wear. Mandrel built in lengths of 60′.

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In addition to the extensive range of wrapped ply and braided cord hoses, Goodyear supply a wide range of hand-built hoses designed to meet special operating conditions.

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RUBBER

The Behaviour of Rubber in Compression under Dynamic Conditions.

By H. McCALLION and D. M. DAVIES. (From an advance copy of a paper submitted to *The Institution of Mechanical Engineers, London*, April 1956, 10 pages, 11 illustrations.)

AT first sight, it would appear that previous investigators have dealt fully with the main variables affecting the behaviour of rubber, e.g., the effects of frequency, amplitude of deformation, and temperature. Closer examination, however, brings out the fact that no attempt has been made to keep the amplitude of deformation constant in any of the previous investigations into the effect of temperature in the lower ranges. It is important that the amplitude of deformation should be kept constant, since both the stiffness and hysteresis energy absorbed per cycle depend on its value. It does not appear that work has been published on the frequency dependence of the hysteresis energy absorbed per cycle at low temperatures, nor even on how the hysteresis energy absorbed per cycle varies with temperature. For these reasons alone, the main investigation described in this paper was initiated, and the results are presented to show the effects of frequency, temperature, and amplitude of deformation on the dynamic properties of rubber.

Experimental data are given in this paper showing the variation of stiffness, hysteresis energy absorbed per cycle, and resilience, with frequency, amplitude of deformation, and temperature. The data have been taken from the results of a series of tests covering the following ranges : Frequency 1·33 to 1200 cycles per min, amplitude 0 to 10% of the free length of the testpiece, and temperature from 125°C to – 60°C. In the latter part of the paper an attempt has been made to develop expressions to agree with the dynamic behaviour of rubber-like materials.

It can be concluded that the behaviour of rubber under dynamic conditions could be predicted from the results of relaxation tests. Such a feature would be of tremendous advantage in the design of rubber components subject to vibration, but it must be pointed out that there are considerable experimental difficulties to be overcome before accurate short-time relaxation data are available.

VIBRATIONS

Vibration Meter with Transistors.

By J. F. KINKEL and M. CARR WILSON. (From *Electronics, U.S.A.*, Vol. 29, No. 4, April 1956, pp. 127–129, 5 illustrations.)

VIBRATION measurements must frequently be made where portability is desirable and power not readily available. The transistor vibration meter described in this paper satisfies these requirements. Operated with conventional vibration pick-ups, it indicates peak-to-peak linear and torsional vibratory displacements, and can be adapted to velocity and frequency analysis of vibration by auxiliary equipment.

The instrument consists of a constant-impedance resistive attenuator, followed by a two-stage integrating amplifier. The integrated output is further amplified and applied to a bridge detector. Bridge current is read on a 500-microampere meter. All power is supplied by two 22½-V batteries.

A particular feature of the circuit used is its ability to increase overall displacement-signal sensitivity by sacrificing the low-frequency response of the integrator. The circuit lends itself to etched wiring. However, the geometry required for instrument compactness and the size of the special low-temperature capacitors require a two-sided etched board. All mounting and through-connections on the board are eyeleted. The use of a two-sided board and the sensitivity of several components to soldering temperatures have precluded dip-soldering. All heat-sensitive components are soldered, using heat-sink pliers as a precaution. All electronic components, including the meter, are mounted on the etched board, which is in turn assembled on the upper half of the die-cast case. Connection to the input and output jacks is by solderless sleeve-and-pin elements.

The two-sided etched board permits use of an etched equivalent to a conventional eight-pole six-position wafer switch. Switch elements and wipers are gold-plated. Switching is accomplished by wipers which short the inner races to the desired outer contacts. By proper orientation of the switch circuits on opposite sides of the board, it was possible to make both wiper discs identical. The selector-switch knob and the indexing mechanism are integral with the case. The mechanical driving connection between the knob and wiper discs is a bar which slides into the slot in the wiper discs. The indexing mechanism has a spring-return action in the test-battery position, returning the switch to OFF upon release, to reduce battery drain.

WELDING

The Behaviour of Spot Welds under Stress.

By J. F. RUDY, R. B. McCAULEY, and R. S. GREEN. (*From The Welding Journal, U.S.A.*, Vol. 35, No. 2, February 1956, pp. 65s–75s, 23 illustrations.)

THE purpose of this paper is to give evidence of the existence of a relationship between four spot-welding parameters. To accomplish this, spot-weld joints were made in 11-gauge Armco iron. These four parameters are as follows :—

(1) The physical strength of the spot weld in tension shear (the coupon is in tension, and the weld in shear).

(2) The mechanism of weld failure when pulled in tension shear. Terms in the literature used to describe these failure mechanisms are shear, button, tear, etc. Only the three failure mechanisms which the authors have called shear, intermediate, and tear were observed in this investigation.

(3) The macro-geometry of the weld cross-section, e.g., the size and shape of the cast nugget and of electrode indentation, the bond area in the faying plane which is not part of the nugget, etc.

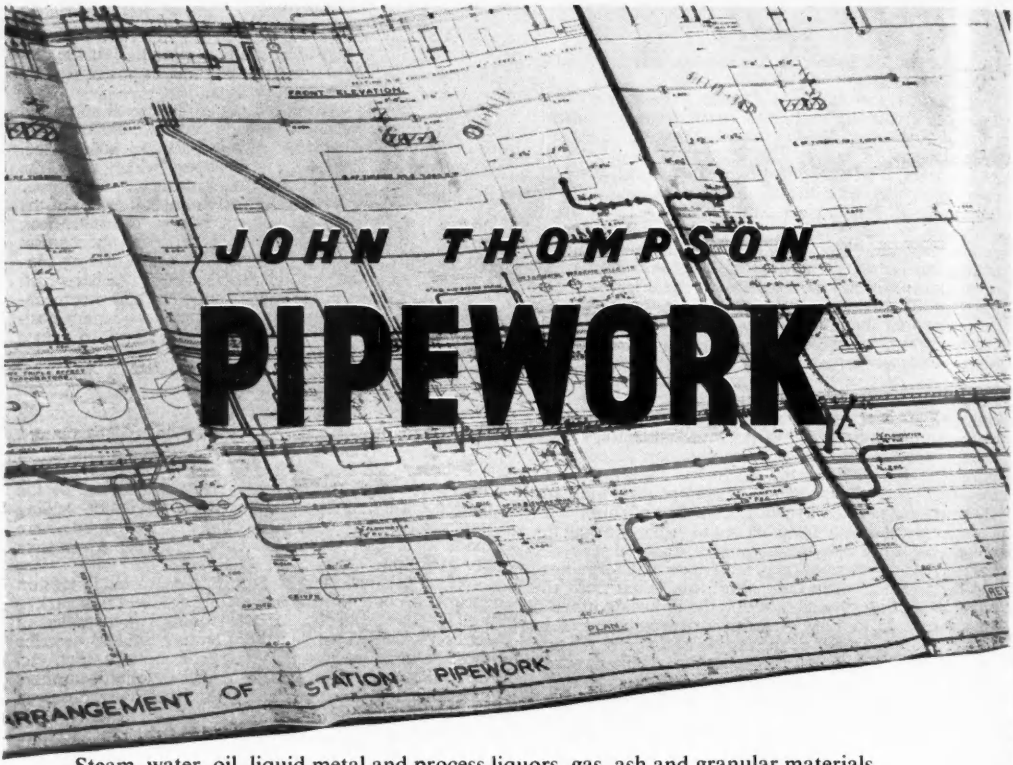
(4) " Sectioned spot shear test " observations of the exposed cross-section of a spot weld as load is applied to the section in tension shear. Half of the spot cross-section was exposed by longitudinally splitting the tension shear coupon. This allows the strain reaction to the application of loading to be traced through the section. The observation technique is explained in the paper.

The four-parameter relationship is established by showing individual correlations between several parameter pairs such that a general interdependence is shown to exist. The parameter pairs which were related for the purposes of this investigation are as follows :—

(a) The spot-weld mechanism of failure (parameter No. 2) is shown to be related to strain reactions observed in the sectioned spot shear test (parameter No. 4). In other words, the occurrence of the various failure systems in whole welds can be explained in terms of the movement of plastic strain as it is traced in similar sectioned half-welds. This validates the sectioned spot shear test as a useful tool for understanding the behaviour of the spot-weld joint under stress.

(b) The failure system of a spot weld when loaded in tension shear (parameter No. 2) is shown to be determined by the macro-geometry of the cross-section (parameter No. 3). This is established by noting that the system of failure changes when the cast nugget development reaches certain stages. A similarity was seen in this respect for all three welding runs studied. Also, this relationship is explainable in terms of observations of the sectioned spot shear test.

(c) Lastly, the physical strength of a spot weld (parameter No. 1) is shown to be related to the weld failure system (parameter No. 2) by observing the similarities of the dependence of each on welding heat for each of the three welding runs used.



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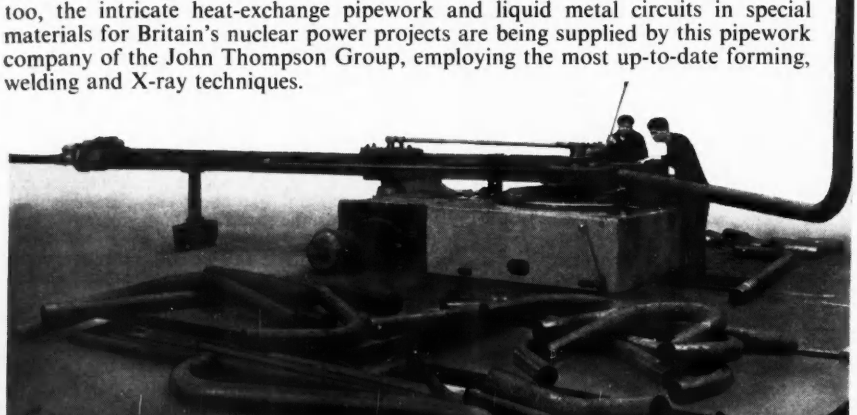

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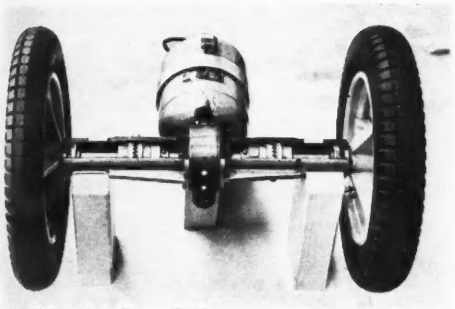
The standard differential, as used in motor transport, occupies considerable space radially, necessitating the centre-line of any axle to which it is fitted to be well above ground level. In the "Tractamatic" drive announced by Watson Oswin Ltd., of Kingston-on-Thames, this disadvantage has been eliminated, inasmuch as the drive unit is contained in an axle casing which is little more than three times the diameter of the actual driving shaft.



The new drive, which is fully reversible, self-engaging, and self-disengaging, permitting over-riding in either direction, provides steerability to one axle under loads of up to half a ton in both forward and reverse directions. The drive, which operates in an oil bath and requires no maintenance other than periodical checking of the oil level, engages automatically immediately after application of the motive power, and returns to the neutral position when the power is withdrawn. When turning a corner there is always a positive drive on the inside wheel but, if it should lose traction and spin, the outer wheel immediately engages, and positive drive is reinstated.

NEW WAVE PULSE GENERATOR

Produced by D.F. Developments Ltd., of London, N.1., a new wave pulse generator, designated "Sonomec", is primarily intended for use in laboratories though the machine also has obvious uses in other sections of industrial and scientific research. The "Sonomec" is, in fact, a mechanical vibrator with great variability within the frequency range of 0 to 200 cps. It consists essentially of a mechanically driven disc diaphragm which transmits vibrations to liquids or solids in the 1-gal capacity processing pot of the apparatus.

The linkage mechanism, driven by a 2-hp electric motor, incorporates a means of adjusting the amplitude of vibration in an infinitely variable manner. Frequency also can be varied without stopping the machine. The standard unit is fitted with a container for processing liquids. In addition, other fitments may be attached, so that electrical components, instruments, etc. can be held firmly and vibrated. The vibrations may be arranged in either a vertical or horizontal plane, or at any angle to suit specific requirements.

Large-capacity wave pulse generators can be designed and supplied for carrying out processes on a commercial scale. In this connection, the "Sonomec" provides a further advantage in that it enables accurate experiments to be made beforehand so as to determine optimum frequency and amplitude of vibration. Thus, a considerable saving can be effected in the capital cost of a large-scale machine, because equipment for varying the vibration frequency and amplitude need not be incorporated, and the generator can be constructed to provide exactly only those conditions required for the particular process.

ENGRAVING AND COPYING MACHINE

Of novel design and unusual compactness, the "Scripta" Model 3R-3D, manufactured by Scripta Machines à Engraver, of Paris, is a three-dimensional pantographic tool of high precision and versatility, designed to carry out engravings in relief or intaglio, as well as to reproduce diecasting moulds and embossing punches. The principal feature of the machine, for the operation of which no special skill or training is required, is the pantograph, in the form of a parallelogram, one of the arms being extended to carry the stylus which traces the master and which produces corresponding movements, at a reduced scale, of the rotating engraving cutter. The amount of reduction required on the work is controlled by means of two screws.

Any type of cutter between about $\frac{1}{8}$ and $\frac{3}{8}$ in. in diameter can be used in the cutter spindle, which is driven through a resilient coupling by a vertically mounted motor, motor spindle speed being variable between 1000 and 12,000 rpm. The cutter spindle is designed so that cutter run-out can be held at less than 0·0008 in. The work-table is adjustable vertically by a screw and controlled by a large-diameter vernier scale. The copy-holding table is also adjustable vertically. The pantograph assembly is provided with a vertical movement, which is adjustable horizontally for precise positioning of the cutter. The table and base are of cast iron with ground top surfaces. Setting lines milled on the top surface of the table, together with a number of tapped holes, permit quick location and fixing of components. The applications of the machine are extended by a series of attachments, which include a dividing head for engraving on cylinders, cones, and circular plates; a pyrographic attachment for engraving on hardened and tough steels; and a diamond for engraving glass.

Ratios of reduction on the pantograph are from 1 : 2 to 1 : 6, enabling 23 different dimensions to be obtained from one guide. The maximum height of work accommodated under the pantograph is 5·3 in. ; with an extra-long vertical column this is increased to over 16 in. The surface covered at one setting with the pantograph set for a 1 : 2 ratio is about $15\frac{3}{4} \times 9\frac{3}{4}$ in.

Unique

"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

C. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N

SUB-MINIATURE ELECTRONIC ACOUSTIC INSTRUMENT

The " Sonatron ", announced by Airsonic Ltd., of London, S.W.1, is an entirely new sub-miniature, electronic, highly sensitive acoustic instrument, specially designed to give a 90-decibel gain, thus making it possible to tune in to sounds and vibrations far beyond the range of the human ear; at the same time, it is adaptable to listening to the internal vibration of really noisy machinery. Vibrations in the vicinity of — 60 decibels can be amplified and clearly distinguished, distortion and general interference being negligible.

The instrument is very simple to operate, only three controls being used. These controls cover a frequency range of 25 to 20,000 cps, and it is possible literally to " tune in " to the frequency required, and to " tune out " or subdue unwanted frequencies. The " Sonatron " is completely portable and independent of outside sources of supply, operating from two miniature batteries, housed in the robust metal case, the dimensions of which are $4\frac{3}{4}$ in. × $3\frac{1}{4}$ in. × $1\frac{3}{8}$ in. In addition to its use as a stethoscope, the instrument will drive most types of measuring instruments, tape recorders, and a specially designed loudspeaker.

This high-gain sub-miniature electronic amplifier has been designed to create an electrical waveform, duplicating the acoustical waveform at a gain of + 90 decibels, and a power dissipation of 15 mW. The industrial probe supplied with the instrument is fully screened, and incorporates a highly sensitive crystal contact microphone and an insulated handle. Also supplied is an electrical probe, which is capable of indicating the presence of live electrical wires at a distance of several feet. Special accessories for certain applications, including small, portable loudspeakers and measuring instruments, are also available.

PRINTED ELECTRICAL CIRCUITS BY XEROGRAPHY

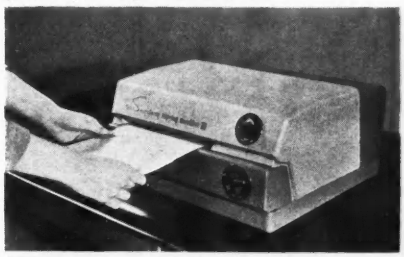
A method of preparation of printed electrical circuits for etching by xerography is announced by The Haloid Company, of Rochester, N.Y. In the new application, the powder image peculiar to xerography—a fast, dry, electrostatic method of copying, previously used chiefly in office and graphic-arts reproduction—is transferred from a " XeroX " selenium plate to a sheet of transfer paper, and thence to the face of a copper-clad laminate. Here the powder forms a photo-exact resist pattern impervious to chemical attack. Since, in the etching step which follows, acid eats away all the copper unprotected by the resist, the result is metal left only where specified by the original circuit drawing. The xerographic powder or resist, having accomplished its purpose, is

then removed by solvent, disclosing the completed print ready for dip-soldering to " pig-tails " or other contacts.

From an original opaque drawing, a copper-clad laminate serving as a printed circuit or wiring board can be prepared for etching in about 10 min, i.e., approximately nine times faster than the photo-resist method and about fourteen times faster than the silk-screen method, the only other processes in common use. Except for the final etching step, the xerographic approach is entirely dry, requiring neither conventional photographic materials nor darkroom facilities. In most cases, because printed circuits are generally small, several identical circuits may be made from one xerographic exposure. The number possible from one cycle depends on the size of the circuit to be produced and the sensitive area of the selenium plate.

HIGH-SPEED THERMAL-REACTION COPYING MACHINE

The " Secretary ", manufactured by the Minnesota Mining and Manufacturing Company, Ltd., of Adderley Park, Birmingham, is a compact desk machine, only 17 in. square by 9 in. high, producing copies of almost any document or plan in 4 sec or less, without the use of inks, negatives, stencils, chemicals, master copies, darkroom techniques, or any kind of preparation or processing. The item to be copied is merely placed beneath a quarto or foolscap sheet of specially treated airmail-weight paper, fed into an aperture onto a moving belt, automatically turning on a special light source, and the completely processed copy emerges from a lower aperture, turning off the light as it is taken away. No special operating skill is required.



The copy is produced by thermal reaction on the copying paper. The non-image or unprinted area of the original reflects the light, while the written, printed, or typed copy absorbs the light and causes a reaction on the special copying paper. The result is that, where there is a mark on the original, an identical mark is reproduced on the paper.

The " Secretary " will reproduce any typed, printed, or written material with a graphite or metallic content, i.e., it will copy typing or printing, carbon copies, lead pencil, stencil ink, some coloured typewriter ribbons, and some coloured inks. It will not copy some ballpoint inks or spirit and gelatin inks.

FOR HEAVY DUTY

PHILIPS TYPE ES 1382

- ★ A clearly visible calibration scale
- ★ High efficiency with low current consumption
- ★ Ample cooling without oil
- ★ Light in weight
- ★ Robustly constructed in drip-proof sheet-metal housing of pleasing design

This plant, with a generous output range, is ideally suitable for general light, medium and heavy fabrications. It is equally good for all classes of maintenance and repair work.

Capacity is 60 to 350 amps, with infinitely variable current adjustment.

Electrodes 12 s.w.g. to 5/16 in.

The plant embodies the finest modern features of welding transformer construction.

Power Factor Correction

Power factor Correction Capacitors can be fitted if required (A 6KVA capacitor is the appropriate size for this equipment).

PHILIPS

PHILIPS ELECTRICAL LIMITED

INDUSTRIAL DIVISION, CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

See us at STAND 319 · INTERNATIONAL MACHINE TOOL EXHIBITION 1956 · June 22—JULY 6 · Olympia · Lond

ARC AND RESISTANCE WELDING PLANT AND ELECTRODES HIGH FREQUENCY GENERATORS · ELECTRONIC MEASURING INSTRUME
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INTERNATIONAL MACHINE TOOL EXHIBITION, 1956

Covering approximately 450,000 sq ft, of which 252,000 sq ft represent stand space occupied by no less than 213 space holders, the International Machine Tool Exhibition will be held this year at Olympia, London, between June 22 and July 6, 1956. In the following pages a preview is given of some of the items to be shown at this Exhibition. A further selection will be included in our June issue.

AMONG a comprehensive range of radial, vertical, and multiple-spindle drilling machines to be exhibited by **James Archdale & Co. Ltd.**, of Worcester, is their new 5-ft mechanical preselect speed radial drill. This machine has two ranges of spindle speeds, i.e., 15 to 1500 rpm, or 10 to 1000 rpm, and 12 feeds, i.e., 0·002 to 0·50 in., or 0·004 to 0·030 in. per revolution, and 5 tap leads. Holes up to 3 in. in diameter in mild steel or 3½ in. in cast iron can be drilled, and speeds can be preselected at any time, with the spindle running or stationary. A single lever on the saddle simultaneously locks or unlocks the saddle on the arm and the arm on the column. A feature of this machine is the power-lock to the arm.

Archdale will also exhibit their No. 785 self-contained hydraulic-feed drill unit, their No. 794 self-contained hydraulic-feed quill-type drilling unit, and their No. 796, size "B", self-contained hydraulic-feed drill unit (Fig. 1). These units can be arranged for mounting at any angle from 30 deg. below the horizontal to the vertical.

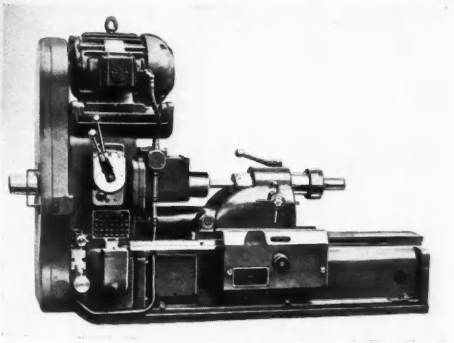


Fig. 1.

In addition to a range of horizontal and vertical milling machines, including Cunliffe & Groom No. 2 plain, vertical, and universal milling machines and attachments, Archdale will also feature their 34-in. milling machine. This improved unit has a more robust spindle drive, capable of running at higher speeds, a 20-hp motor, with a speed range of 15 to 1500 rpm, being fitted. A 12-in. gear, giving a powerful drive at speeds up to 304 rpm, makes this machine eminently suitable for carbide or high-rake milling. The spindle sliding head is provided with an automatic feed and quick traverse, while a magnetic clutch and brake ensure gentle starting and give more precise control to the spindle. The knee has a hydraulic counterbalance, providing easier hand vertical adjustment and a longer elevating-screw life. Twenty-four feeds, from ⅜ to 45 ipm, are available.

Another interesting exhibit from Archdale will be their "Unimatic" standardized unit-construction platen-type transfer machine, which comprises two- and three-station centre-bed units, loading and unloading platen cross-indexing, and hoists. Standard types of extension beds for mounting work-heads, and swarf and platen return conveyors are also featured. Mounted on this machine will be a selection of Archdale self-contained hydraulic feed-unit heads, including Nos. 785, 794, and 796, mentioned above.

Planers, toolroom slotters, and shapers will be featured by **The Butler Machine Tool Co. Ltd.**, of Halifax. In addition to their 12 × 4 × 4 ft No. 5 spiral-electric planer, Butler will exhibit their 6 ft × 30 in. × 30 in. hydraulic openside planer, of new design with a maximum stroke of 6 ft, and a table working length of 6 ft × 28 in. wide, admitting 30 in. under the cross-slide. This machine incorporates a number of important improvements over the previous model, the most outstanding of which is that the drive is a self-contained unit mounted alongside the machine.

In addition to their 8-in. precision toolroom slotter, Butler will also exhibit a 16-in. precision toolroom slotter of entirely new design (Fig. 2). This machine is probably the only one of its type in existence to have been designed from the start to combine large capacity with extreme accuracy and to incorporate all existing features of toolroom slotters. The drive is from a 5-hp motor, mounted in the base of the machine and connected directly to a 6-speed gearbox, the gears of which are of heat-treated nickel-chrome steel with all shafts mounted on ball or roller bearings, while the 6-position gate lever for controlling this gearbox is located at the front of the machine. From this gearbox the drive is taken through a single helical pinion and stroke wheel to a slotted link, which incorporates the ram balance-weight, and thence through

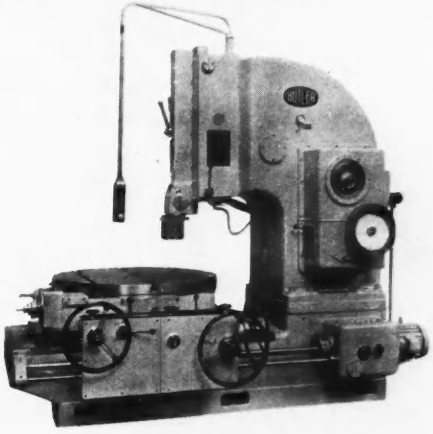


Fig. 2.

What shall we play on it ?

Our repertoire on the Austinlite Rotary is almost inexhaustible. Choose a switching composition as complex as you please and it is a practical certainty that an Austinlite Rotary will not only handle it, but handle it with less fuss and complication and in less space than any other method you can think of.

We can do anything you ask with Austinlite rotaries because every switch is built for its job, no matter how special the job may be.

Rotary switching is 'Simplified Switching'

ask *Austinlite* about it

AUSTINLITE LIMITED, 28 ST. JAMES'S SQUARE, LONDON, S.W.1
TELEPHONE: TRAFALGAR 1954
(A subsidiary of Stone-Chance Ltd., the makers of Sumo Pumps and Stone-Chance Lighthouses)

a connecting link to the ram. The ram can be tilted forwards up to 7½ deg. and carries an all-steel relieving toolbox, which will accommodate tools or tool bars in the horizontal or vertical position and which can be adjusted round the ram end to any angular setting. The ram is controlled from a pendant push-button station giving " start ", " stop ", " inch-forward ", and " inch-return " controls to the ram. The length of stroke is adjusted from the square shaft, which can be operated with the ram in motion or at rest, and the feed operating gear can also be adjusted at any time by loosening one knurled knob and turning another. The 4-ft diameter circular table has the top scraped flat and the tee-slots machined in position, to ensure that they are parallel or at right angles to one another, while the table itself can be locked to the square slide by levers at the front and back which operate bolts running in a tee-slot machined on the underside of the table.

Other Butler exhibits will include an 18-in. super-shaper and a 26-in. super-shaper. A special feature of the latter machine is a hydraulic copying device. A self-contained hydraulic unit is mounted alongside the machine, consisting of a flange-mounted motor driving a Vickers vane-type pump, and complete with stop- and start-buttons, pressure relief valves, and pressure gauge. Mounted on a bracket attached to the side of the body is the tracer head, on a slide giving 6 in. of horizontal adjustment and 4 in. vertical adjustment, while the stylus itself has 4 in. of vertical travel. The template is carried on an angle-bracket attached to the side of the table and, when the machine is used for copying, the standard horizontal feed is engaged, traversing the work past the tool and the template across the stylus.

One of the most interesting among the wide range to be shown by **W. E. Sykes Limited**, of Staines, Middlesex, is their new SPH.8 high-production hobbing machine (Fig. 3). This machine, of particularly robust construction, has been designed specifically for rapid and accurate working. Heavy-duty antifriction bearings are used throughout, and torsional deflection is reduced by the use of large-diameter, tubular-section shafts. Gearing is of ample proportions, involute splines entirely dispensing with loose keys. The maximum capacity is 13 in. diameter by 4¾ in. face width, with pitches up to and including 4 D.P. Spur gears and left- and right-hand helical gears of any helix angle not exceeding 40 deg. can be produced, in addition to splines and serrations. The tooth form obtained is ideal for finishing by the shaving process, as the appropriate tolerances can be attained in the minimum time. Automatic hob-shift provides a long working life for the hob by ensuring that wear takes place evenly across the entire width. The mechanism can be adjusted to act on completion of each component, or the hob can be moved after a predetermined number of parts has been cut. When the hob has moved the permitted distance, a signal lamp is illuminated and pressure on the " return " button returns the hob to its initial position. Alternatively, the direction of movement can be reversed by a change-over switch. The entire cycle of operation of this machine is automatic. Once the component has been mounted on a suitable fixture, it is only necessary to depress the " start " button to commence cutting. On completion, rotation ceases, coolant flow is stopped, and the hob head and work spindle return to their original positions.

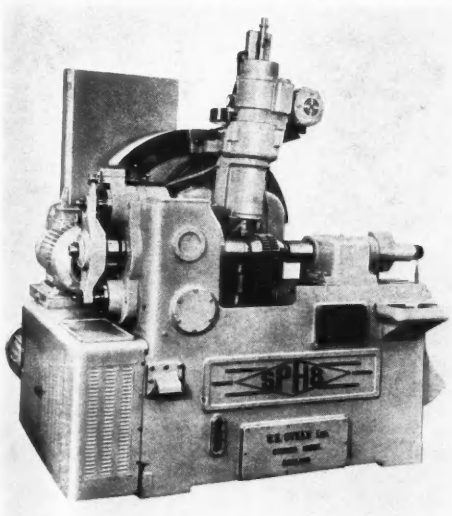


Fig. 3.

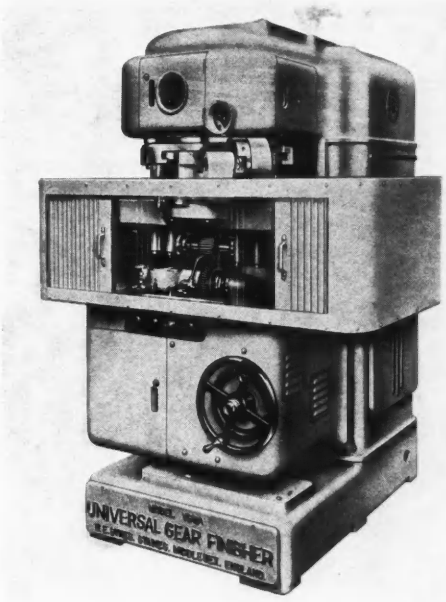
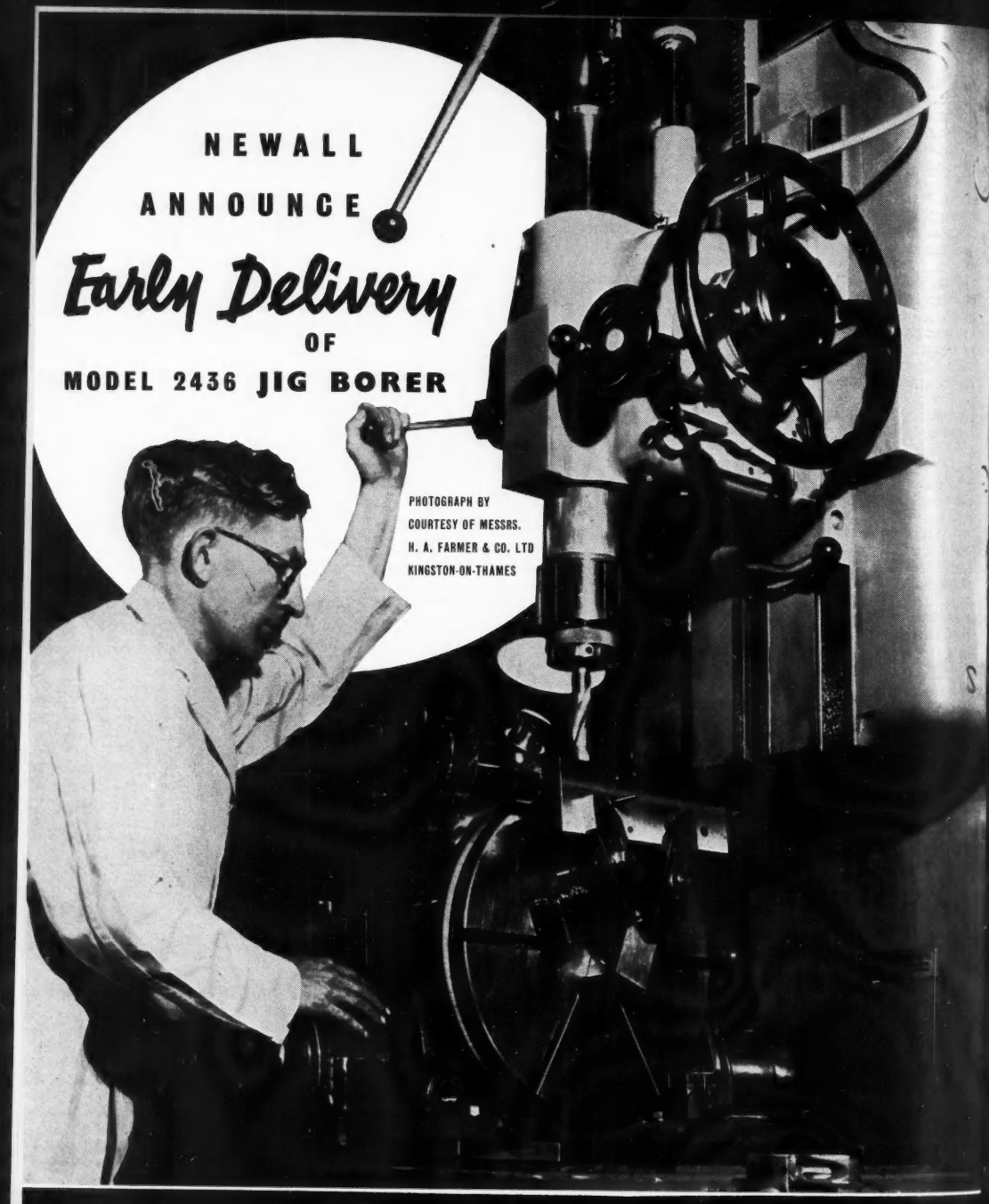


Fig. 4.

Another interesting exhibit from Sykes will be the VS.4A, introduced to supplement the existing range of Sykes rotary gear-shaving machines. This model is not merely a scaled-down version of the VS.8A, 12A, and 18A, but a soundly constructed gear shaver embodying ideal features for small gear production. While the basic principles of operation are similar, the VS.4A incorporates a mechanical in-feed arrangement in place of the electrical system employed in the other machines. Also, the cutter and work are stationed with their centres in the same horizontal plane, as opposed to the vertical disposition adopted in the VS.8A (Fig. 4) and its companion models. The VS.4A is intended to shave gears from ¼ in. to 4 in. in diameter, with a maximum face width of 1 in. The coarsest pitch recommended is 16, and gears mounted on shafts 9 in. long can be held between centres. With shafts up to 6 in. long, the gear can be shaved regardless of the position it occupies. This machine has an extremely high speed cycle, coupled with great accuracy.

Other exhibits by Sykes will include a range of gear-generating machines, helical-cutter sharpening attachments, hobs, cutters, and shaving tools.



BRITAIN'S LARGEST MANUFACTURERS OF JIG BOR

NEWALL

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PETERBOROUGH

TELEPHONE

Prominent among a range of boring, facing, milling, drilling, and tapping machines to be exhibited by **George Richards & Co. Ltd.**, of Altrincham, Cheshire, will be their No. 5 "Electrabore" machine (Fig. 5), a wide-bed model, particularly suited to heavy-duty work and capable of accommodating large and heavy work-pieces on its robust table. The machine to be exhibited will embody several new features, further improving its overall efficiency and reliability.

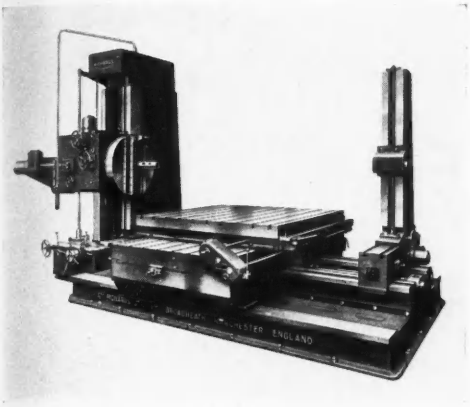


Fig. 5.

Another interesting exhibit from Richards will be their "Victor" 36-in. rapid-production boring and turning mill (Fig. 6). This machine, which is of extremely robust construction, is driven by a 35-hp motor through a mechanically operated gearbox. Twelve speeds are provided to the table, ranging from 12·5 to 250 rpm. The main motor incorporates a dynamic braking device, eliminating the necessity for friction clutches in the gear-box and ensuring a more positive drive to the table. The turret-slide is of the latest design and is balanced by a counterweight. It can be swivelled in either direction to an angle of 45 deg. for taper boring and turning, while the swivel slide is graduated on both sides, and a micrometer dial on the worm-shaft permits the desired angle to be set with extreme accuracy. The turret itself is a hexagonal nickel-chrome casting, with holes in the faces to receive tool bars, etc. It is a most substantial unit, which can be released, rotated, indexed, and re-locked by a single lever. Elevating motion is incorporated for the cross-slide, the motive power for which is a separate 3-hp motor, mounted on top of the machine. The side-head is an entirely independent unit, mounted directly on the column-slide. Eight rates of feed, ranging from 0·0034 in. to 0·135 in./rev, are provided to the side-head. These are entirely independent of the feeds to the turret head and operate in both the horizontal and vertical directions. Feed and rapid power-traverse mechanisms are interlocked, thereby making it impossible to engage these two conflicting motions simultaneously.

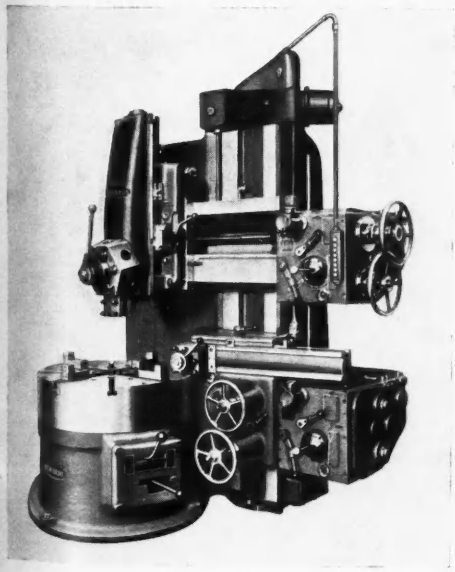


Fig. 6.

Another Richards exhibit will be their No. 2 "VK"-type vertical slot-drilling and keyway-cutting machine. This unit will cut keyways up to 2 in. in width and 30 in. in length. It is gear-driven throughout and operates on the plunge-cut system. No previously drilled hole is required ; the cutter sinks to depth and is automatically changed to horizontal feed, cutting the slot or keyway to any desired length and depth at one cut.

The **Lapointe Machine Tool Co. Ltd.**, of Watford, are now manufacturing a complete range of horizontal and vertical internal hydraulic broaching machines up to 100,000 lb capacity, and surface broaching machines up to 30 tons capacity and a 90-in. stroke. The horizontal range has recently been redesigned, and in consequence the broach capacity has been increased—in particular the H.P.10 machine, which previously had a stroke of 30 in. and now has a stroke of 48 and 60 in. All machines are now equipped with push-button controls. The vertical internal and surface broaching machines also have safety interlocking devices.

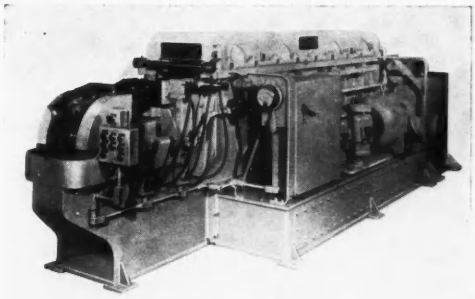
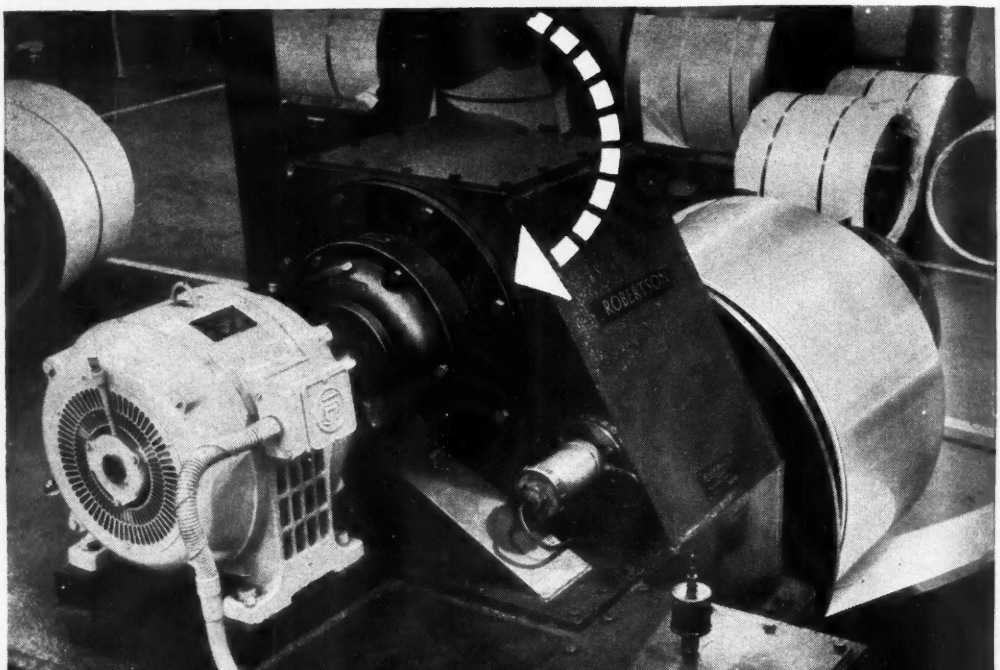


Fig. 7.

This Company has recently added an entirely new range to their products—the Lapointe continuous horizontal broaching machine. This machine is designed for high production, and at present is being made in five standard sizes, with 42, 66, 90, 120 and 160-in. strokes ; the design may be varied to suit individual requirements. A 42-in. stroke machine will be demonstrated at the Exhibition, straddle-broaching the sides of connecting-rod caps. This machine will be equipped with 6 fixtures, from which a production of 400 parts per hour can be obtained at a cutting speed of 25 fpm. If 15 fixtures are used, a production of 1000 parts per hour could be obtained from this machine. The model 50/120 in. continuous horizontal broaching machine is illustrated in Fig. 7.

Among the exceptionally wide range of machines to be exhibited by **Cincinnati Milling Machines Ltd.**, of Birmingham, knee and column milling machines will be represented by a universal and a vertical No. 2 MI, a No. 3 dial type with a new universal overarm, and two

HELIOCENTRIC GEARS IN ACTION No.4



On a strip de-coiler unit

This Robertson de-coiler unit is installed on the strip inspection line at the Shepcote Lane Warehouse of Firth Vickers Stainless Steels Ltd. Coils of stainless steel strip up to five tons in weight, 42 in. wide and .08 in. thick, are dealt with. The unit is required to give a very slow drive to the unwinding coil and Messrs. Robertson's find that " a Heliocentric Gear provides a very neat and compact reducer for the job ".

Heliocentric Speed Reducers are of interest to designers of all types of industrial equipment. Range of manufacture 20:1 to 512,000:1, 1/6 h.p. to 30 h.p. Descriptive booklet on request.

HELIOCENTRIC

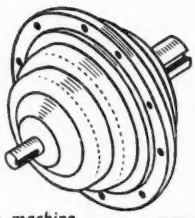


illustration at right shows flange mounted gear as incorporated in the above machine.

A SABEN PRODUCT

SANDERSON BROTHERS AND NEWBOULD LIMITED, ATTERCLIFFE STEELWORKS, P.O. BOX 6, NEWHALL ROAD, SHEFFIELD, 9

other sizes of dial types. The 2 M1 vertical machine is equipped with dog-controlled automatic table cycles.

The production-milling section will be dominated by two new heavy-duty millers, the plain and duplex " Hy-Powermatics ", which are successors to the well-known Cincinnati " Hydromatics ". The range comprises 42 sizes in both plain and duplex styles, and all are available with or without tracer control. An entirely new table drive, known as the "Hydramech ", coupled with a built-in backlash eliminator, facilitates climb cutting. A typical " HyPowermatic " machine is illustrated in Fig. 8.

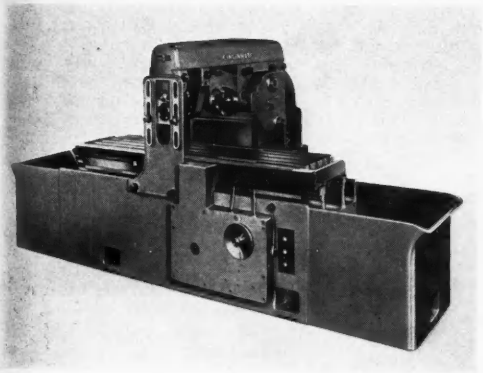


Fig. 8.

In the tool-grinding section the No. 1 and No. 2 cutter grinders and a " Monoset " will be exhibited. The No. 1 cutter and tool grinder is a new machine, incorporating many of the features of the No. 2 machine, but with several design innovations, including a 360-deg. eccentric wheelhead swivel. The " Monoset " is designed to perform all operations necessary in the production of most types of cutters with a single setting of the work-piece. In addition to making special cutters, it can also be used for conventional sharpening operations.

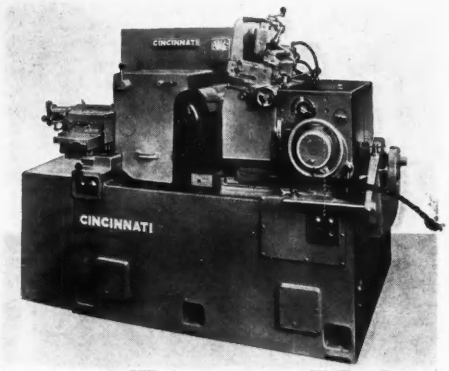


Fig. 9.

Both the centreless grinders to be exhibited are new machines, the No. 0 being an economical producer of small-diameter work, while the new No. 2 (Fig. 9) has several important features, including infinitely variable regulating wheel speed, preloaded, precision ball-bearing slide, and stabilized infeed screw.

An entirely new unit in the range of horizontal and vertical honing machines to be exhibited by **Delapena & Son Limited**, of Cheltenham, is their Model 427 horizontal honing machine, which is suitable for honing bores from to $3\frac{1}{8}$ in. in diameter.

The machine is driven by a $\frac{3}{4}$-hp motor and is provided with a speed variator giving infinitely variable speed control within the range between 100 and 900 rpm. Incorporated in the machine is a speed-control dial to enable the exact mandrel speed to be determined. The machine has a built-in wet honing attachment and a scientifically designed filtration system. The whole of the honing-fluid circulatory system can be withdrawn from the main body of the machine to facilitate re-charging with oil, cleaning, etc. A pump driven by a separate electric motor with independent switching is incorporated in the system. A further feature is the incorporation of an automatic sizing device which is used as a comparator. This enables the size of the work to be determined whilst the machine is in operation and affords a very high degree of control. Other features include the provision of indicator lights to show that the machine and pump motors are in operation. One of these lights is so designed that it can be used as an inspection light.

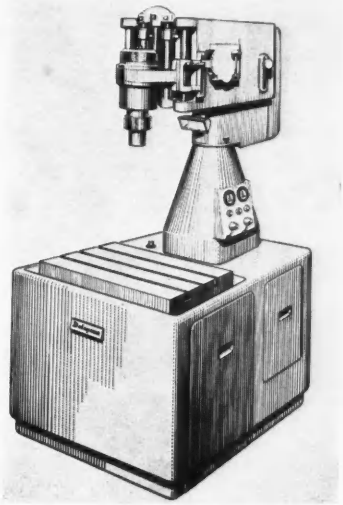


Fig. 10.

Another entirely new Delapena product to be exhibited is their Model 426 6-in. vertical honing machine (Fig. 10). A feature of this machine, which has a working stroke of 6 in., is the provision of a mechanism giving a superimposed oscillation to the hone during processing. The work is located on the table of the machine in a vertical position, and a honing head is rotated and reciprocated in order to carry out the honing process. The machine is fitted with a hydraulically operated centre column which enables the hone to be withdrawn from the work and to be moved to one side to facilitate gauging. This feature also provides three honing stations. The machine is powered by means of an electric motor, and infinitely variable speed control is incorporated, providing a speed range of 70 to 350 rpm.

Other Delapena exhibits will include their Model 276 beam stroking stand, designed specifically for the economical processing of long tubular components ; a full range of external hones for diameters between $\frac{1}{16}$ and 7 in. ; pneumatic clamps ; valve-type and rotary-type induction heaters ; and heavy-duty honing equipment, including specially designed honing heads, hone carriers, and hones.

In addition to examples from their wide range of double-sided presses, **Hordern, Mason & Edwards Ltd.**, of Birmingham, will exhibit seven new open-front presses, Model OP, ranging in capacity from 20 to 100 tons. All

Luke & Spencer Ltd also extend a cordial welcome to old friends on this planet to call at Stand 402 National Hall Gallery Olympia at the

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these presses are built to the same standard design and specifications throughout the range, and are all inclinable, with the exception of the 100-ton machine.

Each of the presses in this range embodies several outstanding features ; thus, for example, the frame is of extremely rigid construction, requiring no tie bars ; the massive crankshaft, of alloy steel, runs in heavy-duty bearings ; ample flywheel energy is available for raising and forming work ; the clutch can be quickly and easily serviced without flywheel removal ; the patented non-repeat mechanism is designed to make repeat strokes impossible when the press is set for single-stroke operation ; ratchet adjustment to the slide is provided—a valuable time-saving feature, combining compact simplicity with heavy-duty construction ; the massive bolster plate has machined tee-slots and an easily removable bed-ring which will accommodate a wide range of tools ; finally, pneumatic balancing of the slide is standard equipment on the 75- and 100-ton models, and is available optionally on the 40- and 55-ton machines.

A newly designed roll-feed attachment will be shown in operation on the 20-ton press. This self-contained unit is integral with a special bed-plate which takes the place of the loose bolster plate on the hand-feed model. Double- or single-roll feeds are available, to take stock up to 6 or 9 in. in width, according to the size of the press. The automatic roll-feed attachment is easily affixed to the machine and quickly removed for storage when not required.

In addition to a representative example from their range of single-crank toggle drawing presses, **E. W. Bliss (England) Ltd.**, of Derby, will be exhibiting their No. 675 high-production press (Fig. 11), with a maximum capacity of 110 tons and a rating of 75 tons for fine blanking dies.

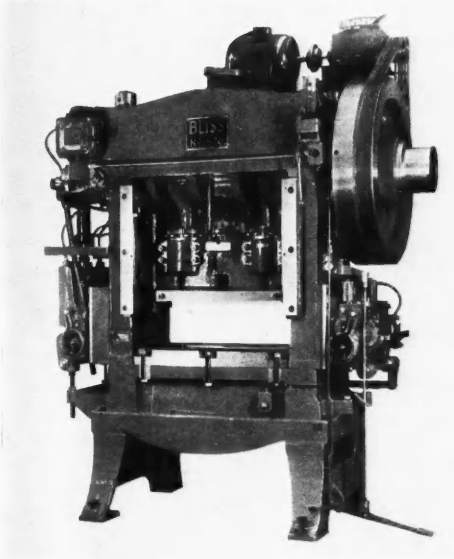


Fig. 14.

In addition, they will be featuring their No. 25 automatic irregular double seaming machine and their high-speed automatic strip-feed press. With the seaming machine all that is required of the operator is to feed the can ends into a magazine. The ends are then fed automatically to the seamer. Only one end at a time can be fed and, if an end is not right side up, it is automatically rejected. The end feed incorporates a " no-can/no-cover " mechanism and will handle straight-flange or curled-edge

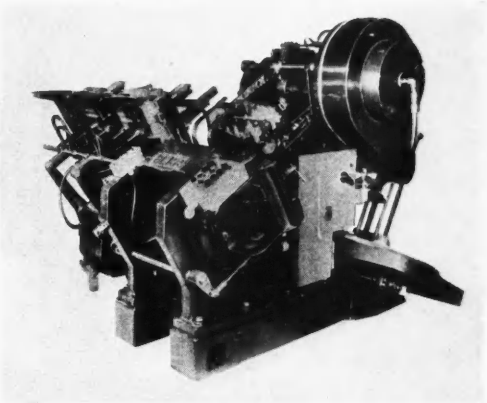


Fig. 12.

stampings, while the seaming head can be equipped with " clover-leaf " seaming rolls or with specially designed round rolls and developed cams.

Developed by the parent Bliss Company in the U.S.A., where it has already been operating successfully, an example of the No. 1831 high-speed automatic strip-feed press (Fig. 12) will be exhibited in action. This particular press, fitted with a double curling and stacking attachment, will be demonstrated producing can end-stampings at a rate of 600 per minute. One of the major features of this press is its precision counterbalanced crankshaft and feed-bar crank, which hold vibration to an almost irreducible minimum, thereby permitting smooth and quiet operation at high speed. Other features include an air-operated disc friction clutch and brake, permitting instant starting ; crank-driven feed bar with adjustable fingers ; and instantaneous stopping of the slide at the top of the stroke.

An exceptionally wide range of equipment will be exhibited by **Charles Churchill & Co. Ltd.**, of Birmingham, **Churchill-Redman Ltd.**, of Halifax, and **Churchill Gear Machines Ltd.**, of Newcastle-on-Tyne, including their 12 in. × 20 in. model automatic hydraulic profiling lathe (Fig. 13), which is designed for completely automatic operation on profile turning work and which will be shown, in this instance, turning spiral pinion forgings. The carriage which carries the hydraulic-tracer valve mechanism and the profile turning tool is provided with an infinitely variable hydraulic feed. By means of a rotating trip bar mounted at the front of the machine, it will take up to four cuts automatically, the length of

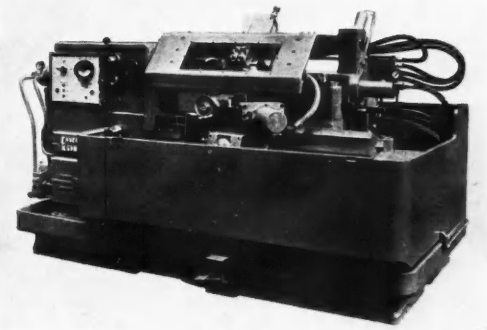
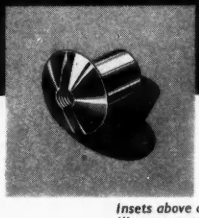
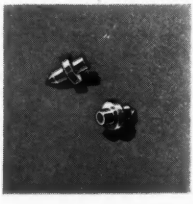


Fig. 13.





Insets above and below illustrate parts enlarged approximately two and a half times.

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cut depending on the positioning of the trips. Special trips mounted below the tracer finger control the depth of each cut, the final pass being taken under control of the template. The machine is fitted with a hydraulically operated rear tool-slide for facing and grooving and undercutting. It has a variable hydraulic feed and can be brought in at a predetermined point during one of the carriage cycles. Using a two-speed main motor and additional trips, the spindle speed can be changed automatically to achieve a more constant cutting speed. An automatic feed change mechanism is mounted on the apron, to enable the feed rate to be changed at any point during any of the four carriage cycles. When necessary, automatic features can be disengaged, and the machine then becomes semi-automatic in operation.

Exhibited for the first time will be one of the new design of " L "-model lathes, the 28L heavy-duty hydraulic profiling lathe, swinging 28 in. and admitting 9 ft between centres. This machine will be fitted with a profiling saddle, on which is mounted the hydraulic tracing mechanism actuated by the Churchill-Redman-designed tracing valve. A template stand, capable of holding templates up to the full capacity of the machine, is mounted at the rear. The hydraulic power for this equipment is provided from a separate hydraulic unit of Churchill-Redman design and manufacture, and this can be used for hydraulic chucking and tailstock operation, when required. A single-lever control brings the profiling slide into operation and also retracts it, so that the machine can be used for centre-lathe work, when required. The 36 P.F. model profile facing lathe (also to be exhibited) is a further development of the " L " model range and is designed to deal with large-diameter work.

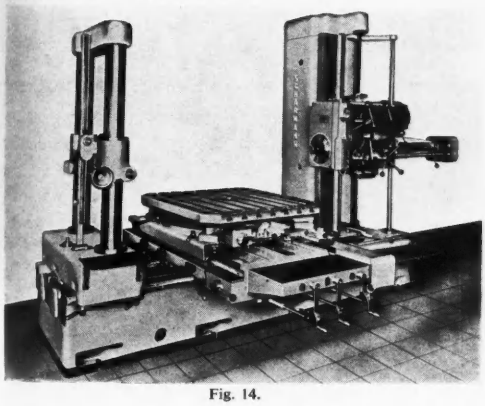

Fig. 14.

In addition to the latest version of the 12 in. × 33 in. Churchill-Fay automatic lathe, a new version of the 8 in. × 21 in. Churchill-Fay automatic lathe will be exhibited. The headstock of this machine will be driven by a separate drive from a 15-hp motor mounted above. The drive to the first-motion shaft will be through an electric clutch and brake, recommended for high-speed short-cycle operations entailing frequent starting and stopping of the spindle at very short intervals. With this arrangement the main drive shaft is started and stopped, but the drive motor runs continuously.

Another new lathe on exhibition by Churchill will be their " Vertimax " vertical-spindle chucking lathe, with a 24-in. diameter swing. Although primarily intended for repetition work, the machine is so easily set up that it can be conveniently used for small quantities. The tool slides, besides being capable of swivelling, have an eccentric mounting, and both of these movements can be freed by slackening two accessibly placed locking screws. The arms carrying the slides can be moved radially and horizontally ; thus, the two tools can be easily and quickly set in relation to the workpiece, and calibrations enable the settings to be noted for future repeats. The tool slides are fully automatic, moving forward simultaneously at the start of the machine cycle with a rapid approach and then at a selected feed rate, followed by automatic retraction with spindle stop at the end of the cycle. They can also be operated by hand, using separate control levers for each slide.

Churchill will also exhibit the Scharman FB.85 horizontal boring and milling machine (Fig. 14), which is an entirely new design, incorporating a unique method of mounting the spindle headstock. The column of the machine consists of two very massive and precisely machined round columns locked together with the column cap, the cast portion of the column, and the bed. Both of the round columns guide the spindle headstock concentrically between the columns. The rear extension of the boring spindle is carried in the cast support column and prevents the entire spindle headstock from deflecting from the centre-line under transverse pressure. The 3½-in. diameter boring spindle is carried in a robust cast headstock, with hardened and ground drive gears. A power-operated rotary table is fitted, and optical measuring scales on cross, longitudinal, and vertical movements give a positional accuracy of 0·0004 in.

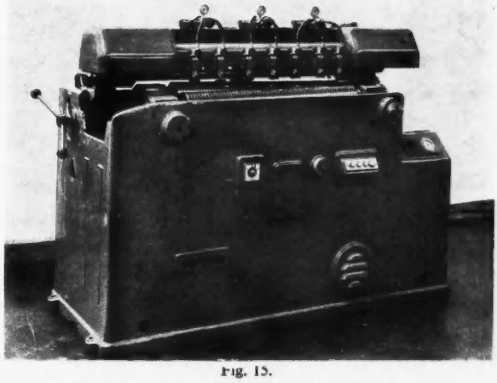

Fig. 15.

Another interesting exhibit will be the " Supfina " SM.62E superfinishing machine (Fig. 15), designed for semi-automatic operation and permitting several diameters on a shaft to be superfinished simultaneously. The workpiece is placed between two rollers rotating in the same direction, and the head, carrying up to seven stone-holders, is lowered onto the workpiece by an air-operated cylinder. As soon as the stones are in contact with the work they commence to oscillate axially at a frequency of 2000 cycles/min with a stroke movement from 2 to 5 mm. After a timed interval the speed of rotation of the rollers is increased to give a final finish. Operating on a seven-bearing camshaft, the cycle time is about 30 sec, and the surface roughness is reduced to approximately 1·5 micro-inches. Also on display will be the Supfina SE.30 and SE.40 single-stone attachments, designed for mounting on lathes for superfinishing large diameters between centres.

Other Churchill exhibits will feature a range of automatics, including Petermann Swiss-type automatics, and the " Conomatic " Model TK, which is a new 6-spindle bar automatic of $\frac{9}{16}$ in. capacity. In addition, two Goss and De Leeuw automatic chuckers will be shown, i.e., the 4-spindle 6 in. × 6¾ in. tool rotator and the 1-2-3 7-spindle tool rotator, the latter being used primarily for boring, turning, facing, and threading operations on work requiring one, two, or three ends, all three ends being machined simultaneously.

Finally, Churchill Gear Machines Ltd., of Newcastle, will exhibit for the first time a new range of completely

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automatic gear-production machine tools, including their new design of Mark IV hobber and the new Churchill 8-in. GCU-model gear-shaving machine, arranged for automatic loading.

Of the extremely wide range of equipment to be exhibited by the **Rockwell Machine Tool Co.**, of London, N.W.2, no less than 27 will be shown for the first time in Great Britain. Of these, in addition to the Giddings & Lewis Model-460-FUAR, which is the first of a new line of boring, drilling, and milling machines, in which all functions are controlled under power, including close-tolerance " inching " to final position, the Giddings & Lewis 350-T boring, drilling, and milling, and die-sinking machine will be featured. This machine will be equipped with British Thomson-Houston three-dimensional tracing equipment and has a 36-in. spindle travel under full tracer control, spindle speeds being from 7½ to 975 rpm. The B.T.-H. three-dimensional system provides simultaneous automatic control of the saddle and headstock, or saddle and table, for die-milling work. Alternatively, the table and headstock may be automatically controlled to give 360-deg. profiling. In die-milling operations, the stepless feed of the tool over the surface of the work remains constant, irrespective of the steepness of the contour, including undercuts.

Fig. 16.

Two " Monarch " machine tools will also be exhibited for the first time by Rockwell, these being the " Monarch " Model-21 " Mona-Matic " and the " Monarch " series-62 " Dyna-Shift " lathe. The " Mona-Matic " machine, which provides a constant cutting speed, has a fully automatic four-cut work cycle and a higher metal-removal capacity and turning speeds than its predecessor. The " Dyna-Shift " lathe swings 20 in. over the bed and has a centre distance of 30 in. Thirty-six speeds and a range of 14 to 1750 rpm, with a headstock ratio of 125/1, are provided, the headstock being provided with two large dials, one for work-diameter setting, and the other for surface-speed setting. This machine automatically and instantaneously calculates spindle speed, whilst the movement of a single lever causes the shift to take place hydraulically and starts rotation of the spindle. By using the pre-selection feature, the operator can set up the machine speed and feed to be used whilst the machine is in operation.

Another interesting exhibit from Rockwell will be the new Thompson 8-in. twin rotary grinding machine (Fig. 16), which has a grinding wheel mounted on a horizontal spindle, the spindle housing being mounted on a vertical slide fitted to a column. The table features a circular indexing platen, on which are mounted two magnetic rotary tables, thereby permitting a new component to be loaded whilst another component is being ground.

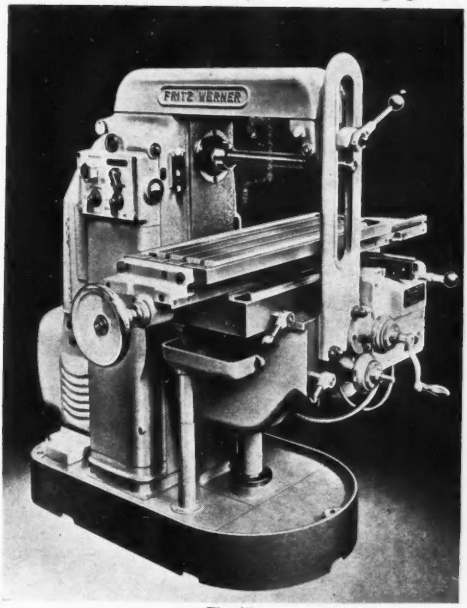

Fig. 17.

Another time-saving feature of this machine is that the downfeed of the wheelhead is controlled by a special torque-control unit, providing rapid approach of the wheel until it actually touches the work.

Among a wide range of Werner milling machines, Rockwell will also exhibit the Werner model 8100 (Fig. 17), which is the smallest horizontal milling machine in the Werner range with a semi-automatic table cycle. This machine, which has been specially designed for the production of smaller components, permits several table cycles to be selected. Operation is by means of a single directional control lever, and when this lever is fully depressed it acts as an emergency switch, stopping the machine. Twenty spindle speeds, from 35 to 2800 rpm, and 32 feeds are provided, and the table, which is 32 × 10 in., has a 16-in. travel.

In addition to the Sundstrand model-22 " Rigidmil ", a versatile production milling machine manufactured in Germany under licence to the Sundstrand Machine Tool Co., of Rockford, Illinois, Rockwell will exhibit another Sundstrand machine, the model-4A multi-tool lathe, which is one of several models forming part of the Sundstrand European manufacturing programme, this particular machine being built in France. This lathe features simple cycle control by the adjustment of dogs on a control disc, and a wide range of cycles can be selected, to suit the individual components being machined. This particular machine will be shown as a fully automatic unit, including automatic loading and unloading.

The ABA model VL.600 jig-boring machine (Fig. 18), also to be exhibited by Rockwell for the first time in Great Britain, is built up on a strong box-type base, having three cross-ribs and heavily reinforced wall openings carrying the column, with vertical ways on which

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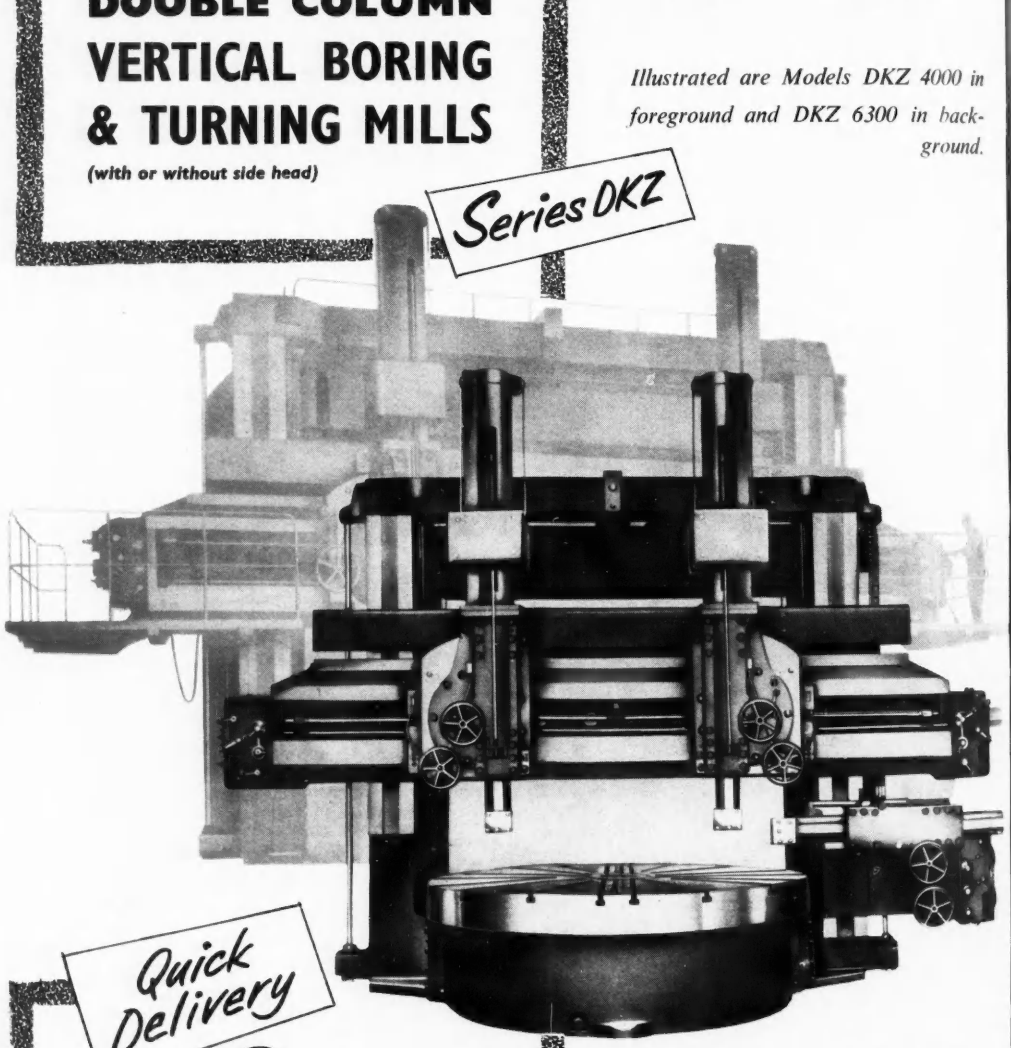
DKZ 4000	13 ft. 0 in.
DKZ 6300	20 ft. 10 in.

Illustrated are Models DKZ 4000 in foreground and DKZ 6300 in background.

Series DKZ



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the boring head slides, the boring head having a long guide of 31 in. and for rough setting being adjusted by hand. A total of 12 speeds, from 37 to 1800 rpm, is obtainable, spindle speeds being selected by two levers located on the front of the head. The table and cross-slide are operated by means of precision lead screws, with fine adjustment. The optical measuring system used (by Leitz) consists of two hair-line microscopes and precision lenses scanning a high-precision measuring scale. Setting accuracy is 0·0002 in., and the microscopes read to an accuracy of 0·00005 in.

Another interesting Rockwell exhibit will be the "Eleroda" model D.1 spark-erosion machine (Fig. 19), designed and constructed at Ateliers des Charmilles S.A., Geneva. Among other important features, the electrical equipment has been carefully designed, with a view to obtaining correct shape. Furthermore, the machine is compact, and all necessary controls are clearly marked and are simple in operation. The work-head is vertically adjustable by means of a handwheel along precision slides, while an absolutely stable electro-hydraulic servo-mechanism for feeding the electrode towards or through the work, while maintaining a constant preset voltage gap, is built into the head. The machine is equipped with a compact table and scales reading in 0·001 in., so that it is not only an easy matter to position the electrode accurately to the work but it is also possible, by means of one electrode, to spark-erode two or more holes accurately and at a predetermined spacing. The machine develops up to 1½ kW at the electrodes, the total power consumption being 3½ kW. By means of a special rotary switch, conveniently located, six distinct speeds can be set. In addition, twenty power outputs can be selected from a dial.

Other new Rockwell exhibits will include a Schutte tool and cutter grinding machine, model WU-2-MS, a precision unit and the latest in the Schutte range ; a Taft-Peirce No. 1 high-precision surface grinding machine, designed for toolroom use or for grinding small parts requiring a high degree of accuracy ; a model KBF-2

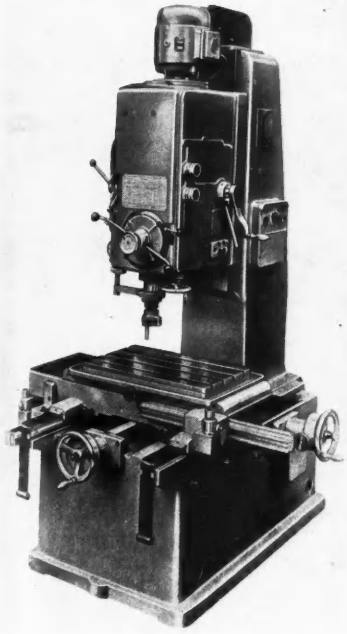


Fig. 18.

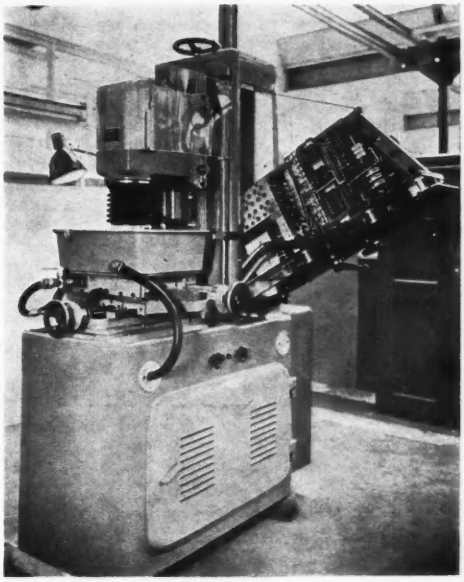
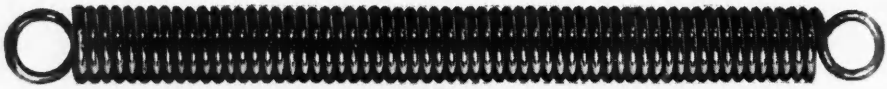


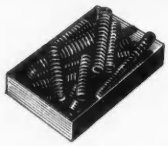
Fig. 19.

Bemag production boring machine, which features pre-selection of co-ordinate settings, spindle speeds, and feeds ; a Hille model BE-2 drilling unit, which can be used for single- or multi-spindle drilling, facing, and boring, and which has a capacity of 1 in. in steel ; and two British Clearing single-action presses, of which one, the model F-2250-48 has a bed area of 48 × 36 in. and a capacity of 250 tons, while the other, model F-2350-84, with a bed area of 48 × 84 in., is equipped with an entirely new air-hydraulic overload-protection device built into the slide of the machine, thereby safeguarding against excessive overloads near the bottom of the stroke.

Prominent among the machines to be exhibited by **Wadkin Ltd.**, of Leicester, will be a range of types demonstrating the high-speed metal-machining techniques recently developed so successfully by this Company.

On exhibition for the first time will be a new universal miller, type W.T. (Fig. 20). This machine has been designed for intricate milling operations on large components in both ferrous and non-ferrous metals, the former being handled by means of interchangeable cap heads. Four basic spindle speeds are provided, ranging from 500 to 3000 rpm, but these can be reduced by the addition of the cap heads to 30 to 180 rpm, or 165 to 1000 rpm. A full range of power-operated movements is provided to the spindle, comprising rise and fall, vertical down-feed, and cross traverse. The spindle can also be canted through 120 deg. The table, with a working surface of 5 × 3 ft, will accommodate a component, 3 ft in height, under the cutter spindle. The table rotates through 360 deg. and, when this movement is employed, work up to 5 ft long by 5 ft wide by 3 ft high can be machined. Longitudinal movement of the table is infinitely variable from 1 to 100 ipm. Hand-operated motion, controlled by large handwheels, is also provided. Hydraulic copying equipment, to special order, can be supplied to cover a 6-in. vertical movement. It can also be applied for controlling the movement of the cutter head across the table on the horizontal arm. Double rotary copying tables are also available. This machine, in addition to its useful application in pattern shops, has equally important applications in machine shops for a large variety of face-milling, profile-milling, contouring for die-sinking, and other purposes.





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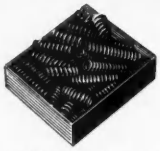

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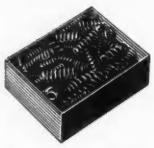

No. 757. Extra Light Compression. 1 gross Assorted. ⅛″ to ⅜″, ½″ to 2″ long, 27 to 20 S.W.G. 15/- each.

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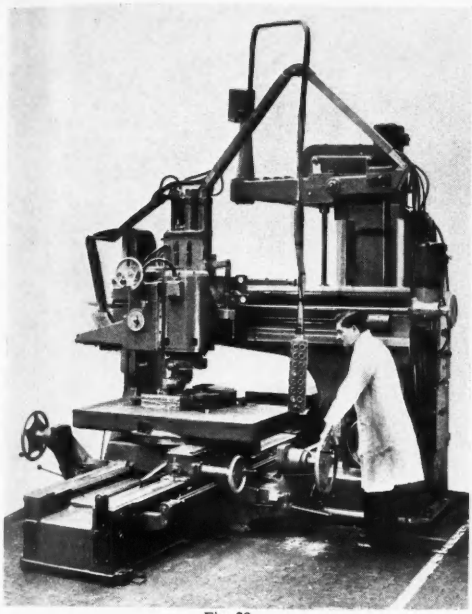


Fig. 20.

Other exhibits by Wadkin will be two forms of their heavy-duty high-speed radial routers. One of these, type L.C., is a new articulated-arm model, offering the advantage of working to close limits of accuracy when face-milling or working off the bottom of the cutter to an accurate depth. The other type is an overhead model, type L.Y.R.3, in which the routing machine is mounted on a saddle on a long bed and is power-traversed along a table fixed to the bed and having a working surface of 12 ft 8 in. long by 2 ft 6 in. wide.

In addition, two Wadkin vertical milling machines, type L.H., differing only in the design of the head, will be shown ; in one case, a high-speed router head is fitted, this being intended for high-speed milling and profiling of non-ferrous sheets, plates, castings, and forgings. The other machine has a quill-mounted recessing head, providing speeds between 1000 and 6000 rpm, and is suitable for milling and recessing of non-ferrous metals and synthetic materials to close limits.

Finally, Wadkin exhibits will include a range of woodworking machines, a hydraulically operated cross-cut saw, a canting-spindle dimension saw, a 24-in. sectional thicknesser, a 16-in. surfacer, and a range of cutter grinding equipment. The woodworking machines will include the Wadkin universal pattern miller, type W.X., which has recently been modified, particularly in the arrangement of the spindle drive.

Exhibits from the **Kerry Group**, comprising **Kerry's (Great Britain) Ltd., Kerry's (Engineering) Co. Ltd., Qualters & Smith Bros. Ltd.**, and **Henry Broadbent Ltd.**, will include, in addition to the well-known ranges of Kerry drills and lathes, Qualters & Smith machine saws, and Broadbent lathes and special machinery, a number of new machines.

The new exhibits will include 1¼ and 1½ in. capacity Kerry all-geared pillar drilling machines, a 1¼ in. capacity Kerry R.3 radial drill, and a Q. & S. 8-in. hacksawing machine, this latter unit being the latest addition to the range of Q. & S. machine saws. In addition, examples of special Broadbent machines will be shown, including a heavy-duty centre lathe, a plane-milling machine and a surfacing and boring lathe.

Other items of interest will undoubtedly be the Kerry conveyorized automatic H.F. ultrasonic cleaning plant and the Kerry ultrasonic drill, both of which have been developed in collaboration with Mullard Ltd.

Included in the range of welding equipment to be exhibited by **Sciaky Electric Welding Machines Limited**, of Slough, Bucks, will be their RAMU.75 universal seam welder, which has a nominal electrical rating of 75 kVA when equipped with a working throat depth of 24 in. This unit has a maximum welding capacity of up to two equal thicknesses of 16 s.w.g. mild steel and is widely used for the fabrication of drums, etc. A feature of this machine is that it can be used for welding both circumferential and longitudinal seams. The change-over from one welding condition to another takes only a very short time. The plant is fully automatic in its operation and is controlled by the latest design of Sciaky dekatron fully synchronous control panel.

Another exhibit will be the Sciaky PAS.75 cross-wire machine, specially designed for manufacturers of wire goods, where numerous welds may have to be made simultaneously. The electrical efficiency of this equipment is fairly high, as the welding transformer is immediately below the welding platens ; it is therefore a very economical machine to operate. The number of wires that can be welded simultaneously depends on the diameter and also on the pitch of the wires.

Other Sciaky exhibits will include two spot-welders, one of these being their PSA.45 portable spot-welder of 45 kVA nominal electrical rating. This unit, in which the actual welding gun is connected to the welding transformer, which is suspended from a gantry, will successfully weld mild steel up to 14-gauge. The other spot-welder is a new machine, specially designed for the welding of light-alloy materials and connected across three phases of a 400-V supply system. The principal advantage of this machine is that it has a high power factor and that a balanced load is drawn from the mains.

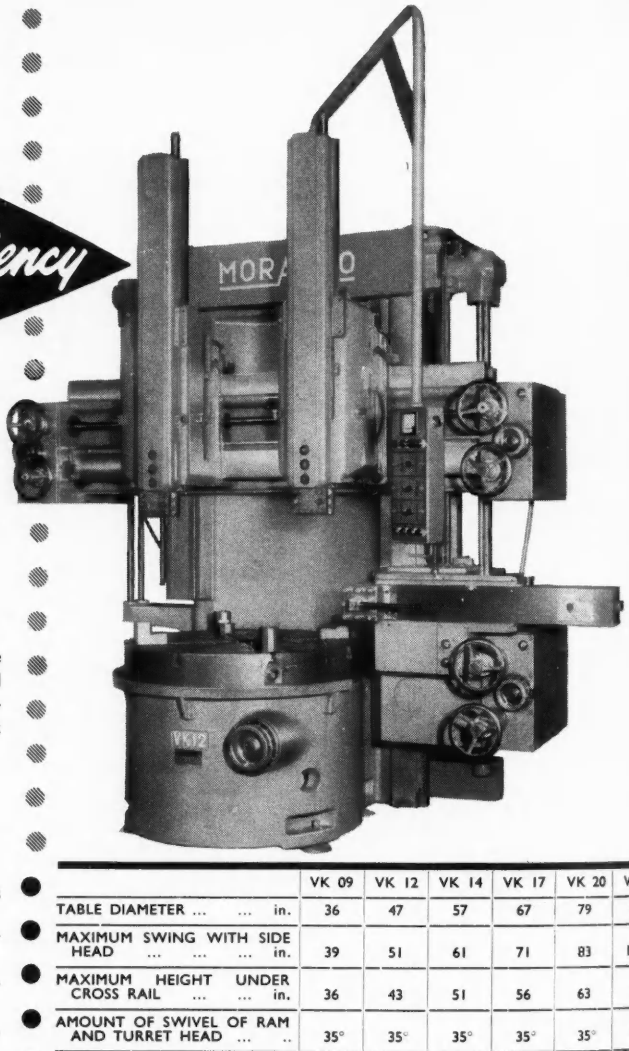
Exhibits by the **Central Tool & Equipment Co., Ltd.**, of Hemel Hempstead, Herts., will include their " Centec " 2, 2A, and 2B universal precision milling machines. Of these, the Centec 2 and 2A models can be supplied for horizontal milling and with vertical heads for vertical milling and drilling at all angles. A wide range of accessories, including power feed to the table, dividing head, and small rotary tables, enhances their usefulness as all-purpose machines for tool-room and production applications. The Centec 2B is a new machine, introduced to meet the demand for a slightly larger model, and is, in fact, an enlarged version of the 2A.

The Centec 3 production milling machine, also to be exhibited, is an automatic-cycle production-type milling machine with an electronically controlled spindle, giving stepless speeds over a very wide range, and a hydraulically controlled table, giving stepless feeds. Cycles are preset by buttons, and the machine can be arranged for pendulum milling.

The Centec 3R two-dimensional production milling machine will be another interesting exhibit, being designed to work to a programme, consisting of any sequence and any number of movements of the table and cutter head. The cycle setting, by the positioning of buttons in slots, is extremely simple. Furthermore, no cams are required, even for the most complicated set-ups.

Other Centec exhibits will include the Centec 3P profile milling machine, in which profiling is effected by a hydraulic tracer valve, ensuring accurate reproduction, and permitting angles up to 50 deg. to be copied ; the Centec auto-pneumatic copying table, in which indexing is effected by pressing a button and without the need for changing indexing plates ; and the Centec pneumatic vice, which consists of a combination of an air cylinder and a system of toggle actions, resulting in compactness, high pressure, and long stroke.

High Speed Efficiency



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3. Table runs in outsize taper roller bearings.
4. The heaviest workpieces can be accommodated.
5. Very high cutting speeds in steel, etc., can be obtained.
6. Simplicity of operation: All controls are centralized in a movable pendant.
7. Pre-set automatic stops and hydraulic copying available.
8. Hydraulic pre-selection of table speeds.

	VK 09	VK 12	VK 14	VK 17	VK 20	VK 25
TABLE DIAMETER ... ... in.	36	47	57	67	79	98
MAXIMUM SWING WITH SIDE HEAD ... ... in.	39	51	61	71	83	103
MAXIMUM HEIGHT UNDER CROSS RAIL ... ... in.	36	43	51	56	63	78
AMOUNT OF SWIVEL OF RAM AND TURRET HEAD	35°	35°	35°	35°	35°	35°
STANDARD SPEED RANGE, 16 SPEEDS ... ... r.p.m. (Other ranges available on request)	8–140	6–180	5–150	4–120	3–90	2–60
MAIN MOTOR POWER (1,500 r.p.m.) h.p.	41	41	52	52	52	65
APPROX NETT WEIGHT KGS.	13,500	17,800	21,600	25,600	30,100	37,600

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Participating in the International Machine Tool Exhibition for the first time, **Ferranti Ltd.**, of Hollinwood, Lancs., will be exhibiting a milling machine producing three-dimensional parts from the solid under the control of a magnetic tape prepared by a special digital computer. The illustration (Fig. 21) shows the machine equipped with the system, together with the control unit in which the magnetic tape is played back.

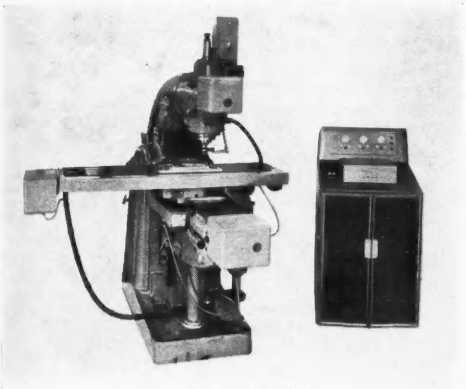

Fig. 21.

One of the most interesting parts of the control system, which will be fully demonstrated, is the unique digital measuring device which is capable of a degree of accuracy matching the capabilities of the most precise machine tool ; at the same time, it is simple and entirely free from mechanical wear. The system as a whole is applicable to any machining operation both where continuous control of the position of the tool is required, as in milling and turning, or where co-ordinate positioning is called for. The utilization of individual tools is increased many times by the use of the system, which can be incorporated in many existing types of machines. The entire system, including the preparation of the tape, has been designed so that it can be operated by personnel without any specialized training.

A comprehensive range of flexible-shaft and polishing-shop equipment will be exhibited by **B. O. Morris Limited**, of Coventry. The flexible-shaft equipment will include a wide variety of standard equipment, a new Scheer 4-in. belt sander/grinder, a new glass-bevelling machine, and a rail-drilling machine. In the polishing-machine/abrasive-belt-machine section, exhibits will include a complete range of polishing lathes and abrasive-belt machines, a gear deburring machine, and a range of consumables. In addition, a representative selection of rotary and straight-line automatic polishing machines and of semi-automatic polishing machines will be featured.

Other Morris exhibits will include barrelling equipment, including the simplified barrelling method, a range of air grinders, filters, and lubricators, a selection of new multi-purpose, multi-head milling/drilling machines, and a number of special-purpose machines, including various gas-turbine-blade processing machines and a twin brushing machine. In addition, a full range of " Morrisflex " rotary cutters, files, mounted points, and industrial wire and fibre brushes will be shown.

A number of demonstration units showing various systems of control and protection for machine-tool drives will be exhibited by **Crompton Parkinson Limited**, of London, W.C.2. One such unit will feature a lathe driven by a ½-hp motor, arranged for simple control of speed by means of a hand-operated regulator, which causes the armature voltage to vary, giving motor speeds up to 1500 rpm at constant torque. At higher speeds a field rheostat comes into action and provides a constant horsepower output. This combination of constant-torque and constant-horsepower characteristics is designed to drive the average machine tool with variable speed over a wide range in the most economical manner. It is expected that similar equipment up to 2 hp will shortly be in production.

A second demonstration unit will feature the Crompton Parkinson variable-overload device. This consists of the recently introduced contact-making ammeter, an inexpensive device which affords reliable overload protection for electrically driven machines. It can be set to trip out an electric motor at any required value of overload. In this instance, the demonstration will be given on a ¼-hp motor, but the device can be used for any size of motor if a current transformer is connected in line.

Static machine exhibits will include a number of motors in the C.P. fractional range, and several standard industrial-type squirrel-cage induction motors in the Company's " KLOSD " range. Fractional-range exhibits will include single-phase, three-phase, and d.c. machines. All have design features which make them particularly suitable for machine-tool applications. The motors to be shown are standard foot-mounting machines, but various other forms of mounting, i.e., resilient and flange—with and without feet—can also be supplied. Among the representative selection of " KLOSD " totally-enclosed, fan-cooled induction motors will be two standard foot-mounting and two flanged endshield-mounting machines. These range from 1 to 7½ hp. In addition, a 5-hp 4-pole sectionalized machine will be exhibited.

Representative examples of standard units from their wide range of hydraulic equipment, as used throughout the machine-tool industry in such applications as table and tool drive and control, hydraulic copying attachments, and automatic-cycle operations, will be exhibited by **Keelavite Rotary Pumps & Motors Ltd.**, of Allesley, Coventry. Equipment on view will include gear-type units which may be used as reversible hydraulic pumps or motors without any modification ; double-acting cylinders in a variety of bore sizes and mounting styles ; and a whole range of direction, pressure, and flow control valves.

Fig. 22.

A particularly interesting Keelavite exhibit, to be shown for the first time, will be their new hydraulic power pack, specially designed to simplify and centralize the installation of hydraulic equipment in machine-tool and similar applications. With the exception of the cylinders or motors actually operated, all hydraulic equipment, including pump, filter, air cleaner, pressure control, volume control, and recording instruments, is built into the tank unit, forming a composite hydraulic power and control assembly, made up from standard hydraulic units. The type illustrated in Fig. 22 measures 36 × 18 × 27 in. overall height, and incorporates a 7-gpm, 1500-psi pump, which is driven at 1430 rpm by a

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3-hp electric motor. Two pressure-outlet lines are used, each being fitted with its own volume (speed) control valve. One pressure control and gauge serve both outlet lines. Different-capacity pumps and alternative control-valve arrangements are available to suit individual requirements. For ease in servicing, all valve-gear is mounted on a detachable panel which, when removed, permits access to the pump and filter. An air cleaner and an oil-lever indicator are also incorporated in a reservoir of 30 gal capacity.

In addition to G-bond wheels, which have proved so successful in the field of precision and semi-precision grinding, the **Norton Grinding Wheel Company Limited,** of Welwyn Garden City, Herts., will exhibit their new K-bond " Crystolon " wheels, together resinoid, vitrified, and metal-bonded diamond wheels, intended for the efficient grinding of carbide tools. B11 resinoid wheels, one of the applications for which is in high-speed fettling, will also be featured.

Other Norton exhibits will include their BD reinforced wheels, which have been specially designed for use on right-angle portable grinders and heavy-duty sanders, their B9 cutting-off wheels with F-sides, and Bohr-Manning coated abrasives. Finally, particular emphasis at the Exhibition will be laid on " Speed-Wet Metalite " fibre discs and " Metalite " cloth belts.

Among a representative selection of products, **Philips Electrical Limited,** of London, W.C.2, will be exhibiting two new items of special interest. One of these is a range of ignitrons fitted with thermostats, which serve to economize on cooling water and to protect the ignitrons against overheating. The second item is an improved version of their PR.9151 roughness tester (Fig. 23), a portable, hand-operated electronic instrument for measuring surface finish between 1 and 250 micro-inches C.L.A. Individually calibrated comparison stand-

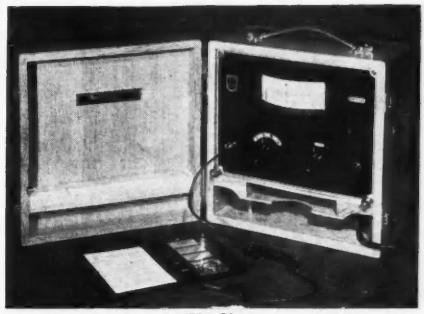

Fig. 23.

ards now make possible even more accurate measurements of finish. The unit is extremely simple to operate and can be used in the workshop by semi-skilled personnel. The instrument can be employed for sampling checks before assembly or despatch ; it can also easily be taken into the workshop for test readings whilst components are still on the machine. Measurements are obtained by comparison with a set of standards of known surface roughness. Other standards may, however, be used to suit individual requirements, e.g., samples from normal production. The type of material is not confined to metal ; in fact, the equipment is equally suitable for measuring the finish on ceramics, plastics, etc. Furthermore, it can be used for readings on most component shapes, including those difficult of access. The small pick-up (less than the size of a cigarette) can be inserted into tubes with an internal bore of only $\frac{3}{8}$ in. Nevertheless, the butterfly-shaped grip provides the machine operator with a firm hold, even when using the pick-up with oily hands.

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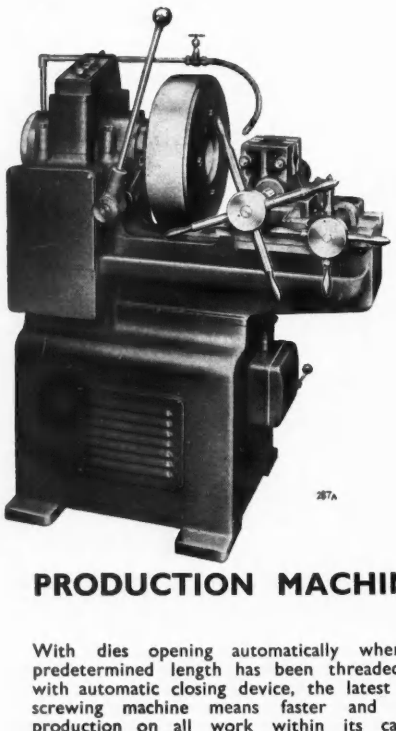

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NEWS OF THE MONTH

PERSONAL

Mr. Alan Aikin, formerly with Mirrlees Bickerton & Day Ltd., Stockport, has been appointed assistant publicity manager in charge of publicity and public relations with Hadfields Ltd., Sheffield.

Sir Donald Anderson, deputy chairman of P. and O. Steam Navigation Co. Ltd., 122 Leadenhall Street, London E.C.3, has been elected President of the Institute of Marine Engineers, in succession to **Mr. H. A. J. Silley.**

Mr. F. A. Bailey, A.M.I.Mech.E., A.M.I.Prod.E., Mr. E. Harris Booth, A.M.I.M., Mr. H. Cotton, B.Eng.(Hons), A.M.I.C.E., Mr. K. B. Crompton, Mr. J. F. Squire, Mr. Frank Warrilow, F.C.I.S., and **Mr. George Wood,** have been appointed local directors of Hadfields Ltd., Sheffield 9.

Mr. R. F. Bishop, A.M.I.Mech.E., has been appointed chief engineer (special developments) and **Mr. D. S. Hudspeth, A.M.I.C.E.,** chief engineer (petroleum equipment) of Whessoe Ltd., Darlington.

Major W. R. Brown, D.S.O., has been elected vice-chairman, and **Mr. T. K. Hargreaves, D.S.O., M.A., A.M.I.Mech.E.,** has been elected a director, of The Power-Gas Corporation Ltd., Stockton-on-Tees.

Mr. W. Lindsay Burns, has relinquished his post as managing director of Henry Balfour & Co. Ltd., after 27 years service, but will remain chairman and will act in a consulting capacity for the company. He will also remain chairman and managing director of George Scott & Son (London) Ltd., Ernest Scott & Co. Ltd., and Enamelled Metal Products Corporation (1933) Ltd. He will retain his responsibilities as senior vice-president of Dominion Scott Baron, Toronto, chairman of George Scott (Australia) Pty. Ltd., director of Les Fours Lecocq, S.A., Brussels, chairman of Balfour Lecocq Ltd. and chairman of The Hillside Foundry and Engineering Co. (Cupar) Ltd., Avertay Works, Tayport. **Mr. Lindsay Burns Jr.** and **Mr. I. M. O. Hutchison,** have been appointed joint managing directors of Henry Balfour & Co. Ltd.

Dr. N. Carpenter, A.M.I.Mech.E., has been appointed technical sales manager of Ferodo Ltd., Chapel-en-le-Frith, Stockport.

Viscount Chandos, D.S.O., M.C., has been re-elected President of the British Electrical Development Association, 2 Savoy Hill, London W.C.2. **Mr. H. J. Randall, C.B.E., F.C.I.S., Comp.I.E.E.,** chairman of the London Electricity Board, **Mr. S. F. Steward, C.B.E., M.I.Prod.E.,** ex-chairman of the South Western Electricity Board, **Mr. E. R. Wilkinson, C.M.G., M.I.E.E., M.I.Mech.E.,** former chief commercial officer of the C.E.A. and **Mr. E. H. Mullens, B.Sc., M.I.E.E.,** ex-chairman of the North Eastern Electricity Board, have been elected vice-presidents. **Mr. D. Bellamy, O.B.E., D.L., F.A.C.C.A., F.C.W.A., Comp.I.E.E., F.S.S., F.R.Econ.S.,** chairman of the Yorkshire Electricity Board, has been elected chairman, and **Mr. W. S. Lewis, C.B.E., J.P., Comp.I.E.E.,** chairman of the Midlands Electricity Board, vice-chairman of the Council.

Mr. E. W. Colbeck, who joined Hadfields Ltd., Sheffield, in 1947 as research and metallurgical director, has been appointed managing director of Hadfields Steels Ltd. **Major H. G. Freeman,** has been appointed managing director of Hadfields Foundry and Engineering Ltd. and has been elected to the Board of Hadfields Steels Ltd. **Mr. J. F. Squire,** has been elected to the Boards of Hadfields Steels Ltd., Hadfields Forgings Ltd. and Hadfields Foundry and Engineering Ltd. **Dr. J. R. Rait,** has been elected a director of Hadfields Steels Ltd. **Mr. Arthur Henry Waine,** has been appointed managing director of Hadfields Forgings Ltd. and is joined on the Board by **Mr. R. Lamb, Mr. G. Wood, Mr. E. H. Booth** and **Mr. J. F. Squire.**

Mr. P. Bernard H. Cuff, has been elected a director of Solartron Electronic Business Machines Ltd., Thames Ditton, Surrey.

Sir Holland Goddard, who has now made a considerable recovery from his recent illness, has relinquished his executive appointments as chairman and joint managing director of Wadkin Ltd., Green Lane Works, Leicester. He will, however, retain his seat on the Board and has been elected President of the company. **Mr. J. B. Bullivant, F.C.A.,** has been elected chairman, and **Mr. L. Austin,** joint managing director, has been appointed managing director.

Mr. I. S. Horabin has been appointed sales manager of Harold Andrews Sheepbridge Ltd. and **Mr. R. D. Millar** has been appointed North Western area representative of Sheepbridge Stokes Ltd., Mr. Miller will operate from Liverpool Road, Longton, Preston, Lancashire.

Mr. R. F. Hunt has been appointed to the Board of Dowty Group Ltd., Cheltenham.

Mr. W. C. Huston has been appointed manager of the Lamp Sales Division, and **Mr. C. W. M. Phillips, A.M.I.E.E., F.I.E.S.,** manager of the Lighting Sales Division, of the A.E.I. Lamp and Lighting Co. Ltd., Crown House, Aldwych, London W.C.2. **Mr. O. W. J. Farmer** has been appointed manager of the Publicity Division.

Mr. Hartford M. King, described in our previous issue as Mr. H. Mayer King, has been elected to the Board of Geo. W. King Ltd., Argyle Works, Stevenage, Hertfordshire.

Mr. C. N. Kington, M.B.E., group manager of the B.I.S.R.A. Sheffield laboratories, has been appointed, in agreement with the B.I.S.R.A., research superintendent of the Cutlery Research Council, Light Trades House, Melbourne Avenue, Sheffield 10.

Mr. J. B. McRostie, A.M.I.E.E., general sales manager, and **Mr. G. T. W. Whitehead, M.I.Mech.E.,** general works manager, have been elected to the Board of Johnson and Phillips Ltd., Charlton, London S.E.7.

Mr. D. R. Mackie has been appointed managing director of Monsanto Chemicals Ltd., 8 Waterloo Place, London S.W.1.

Mr. John Meager has been appointed works office manager at the Plymouth works of Acheson Colloids Ltd. **Mr. D. E. H. Hamilton** and **Mr. E. Matthews** have been appointed technical sales representatives.

Mr. Paul C. Mitchell, Jr., has been appointed sales manager for the Aircraft Equipment Division of Consolidated Diesel Electric Corporation, Stamford, Connecticut, U.S.A. **Mr. George L. Riggle** has been appointed works manager.

Mr. P. E. A. Talbot has been appointed technical sales and service manager of S. Smith & Sons (Canada) Ltd. to represent Smith's aviation interests in Canada and the United States.

Mr. E. H. Morland has been appointed a director of The Uganda Co. Ltd., Tower Hill Station Buildings, London E.C.3.

Mr. N. P. Newman, chairman and managing director of Newman, Hender & Co. Ltd., has been re-elected chairman of the Council of the Ironfoundry Association.

Mr. Cyril Newton has been elected chairman of the Board of Williams & Womersley Ltd., Wakefield, in succession to **Mr. A. W. Boulton** who has retired. **Mr. Cyril Newton** and **Mr. Frank G. Beard** have been appointed joint managing directors.

Mr. C. F. Nossiter, A.M.I.Mech.E., A.I.Mar.E., has been appointed chief engineer of J. A. Prestwich Industries Ltd. He will be operating at the company's new drawing office and research department at Chelmsford Road Works, Southgate, London N.14.

Mr. L. S. Robson, M.C., M.Sc.Tech., M.I.Mech.E., has been appointed assistant chief mechnical engineer of Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17. **Mr. D. M. Smith, F.R.S., D.Sc., M.I.Mech.E., F.R.Ae.S.,** has been appointed chief engineer, Mechanical Engineering Development; **Mr. J. S. Hall, B.Sc.(Tech.), A.M.I.Mech.E.,** chief engineer, Steam Turbine Engineering Department; **Mr. W. H. Darlington, M.B.E., Ph.D., M.Sc.(Eng.), A.C.G.I., D.I.C., M.I.Mech.E., A.F.R.Ae.S.,** chief engineer, Gas Turbine Gear Engineering Department; and **Mr. J. V. Bigg, M.A., A.M.I.Mech.E., A.M.I.Mar.E.,** chief engineer, Condenser and Heat Exchange Engineering Department.

$$\frac{d^2\theta}{dx^2} + \frac{1}{x}\frac{d\theta}{dx} - \frac{\theta}{x^2} = -\frac{V}{D}$$

$$\rho\left(\frac{d\theta}{dx} + \frac{1}{m}\frac{b}{x}\right) = M_A$$

$$n\left(\frac{\theta}{\lambda} + \frac{1}{m}\frac{d\theta}{dx}\right) = M_B$$

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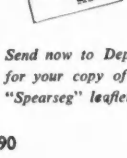
SEGMENTAL SAWS



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Mr. **Richard T. Sutton, A.M.I.E.E.**, has been appointed chief engineer of the Lancashire Dynamo & Crypto Ltd., Willesden Works, Acton Lane, London N.W.10.

Mr. **John G. Thom, A.M.I.W.**, has been appointed sales manager for Northern Ireland for British Oxygen Gases Ltd.

Following the appointment of Mr. **J. T. Thornhill** as executive director of Siemens-Ediswan Ltd. and the relinquishment of his position as manager of the Motherwell works of Metropolitan-Vickers Electrical Co. Ltd. and superintendent of their Instrument & Meter Department, Trafford Park, Mr. **J. E. A. Heale, A.M.I.P.E.**, has been appointed works manager of the Motherwell works, and Mr. **E. Turnbull**, superintendent of the Instrument & Meter Department, Trafford Park. Mr. **R. W. D. Jack, B.Sc.(Eng.)**, has been appointed assistant superintendent of the Instrument & Meter Department at Trafford Park, and Mr. **F. B. Lawrence**, assistant superintendent at Motherwell. Mr. **G. L. Brown** has been appointed assistant superintendent of the X-ray Department at Motherwell.

Mr. **D. B. Wright** has been appointed sales manager of Kerry's (Great Britain) Ltd., Industrial Division, Warton Road, London E.15, in succession to Mr. **A. H. Watts**.

Mr. **F. P. Wright** has been appointed strip mill manager, and Mr. **J. K. Walshaw**, assistant strip mill manager of the Steel, Peech and Tozer branch of The United Steel Companies Ltd. Mr. **W. E. Alexander** has been appointed rolling mills superintendent, Mr. **N. D. Thomson**, Brinsworth mill manager, Mr. **F. Tew**, assistant Brinsworth mill manager, Mr. **W. F. Stroughair**, assistant bar mill manager, Mr. **N. Stones**, assistant manager 10in. and 14in. mills, and Mr. **G. Morris**, shift superintendent, bar mill.

FOREIGN INVESTMENT IN CANADA

A survey of foreign investment in Canada published recently by the Dominion Bureau of Statistics reveals that, although 85% of Canada's growth since the war has been financed by domestic capital, of the total of $12,469m. of new foreign capital invested in the Dominion (in 1954) no less than $9,622m. (about 77%) was of United States origin. At the end of 1953, American interests controlled about 55% of the capital invested in the Canadian mining and smelting industries and in the exploration and development of petroleum resources, and over 40% of the capital in the manufacturing industries. Much of this capital was concentrated in a few particular fields, with the result that American-controlled firms were responsible in 1954 for 98% of Canada's output of motor cars and 78% of her output of rubber goods. The Dominion's foreign trade has become increasingly dominated by trade with the United States : in 1954, 60% of its exports went over its southern border, as compared with 34% before the war, while nearly 74% of its imports were from the United States, as compared with about 62% in 1938. To redress, partly at least, Canada's undue dependence on the United States economy, many Canadians would like to see more capital coming from other sources—particularly from the United Kingdom, as Canadian exporters are anxious that Britain should have a larger source of dollar earnings with which to buy Canadian goods. Britain, too, would like to see a higher rate of British investment in Canadian industry, for Canada is potentially the richest Commonwealth territory.

The survey points out that since 1949 there has been an increase in British investment (in 1954 the total was $2,143m., as compared with $1,608m. in 1949) and there have been some notable ventures, such as Grosvenor Estates' Annacis Island scheme, I.C.I.'s $20m. investment in an Ontario synthetic fibre plant, A.V. Roe's $40m. aircraft plant and, announced only last month, the formation of a new Canadian company to promote, finance, and develop new enterprises, with a paid-up capital of $8m., partly British owned. However, in spite of the drop in the value of money since before the war, United Kingdom investment in Canada in 1954 was less than in 1939 and represented only 16% of total foreign investment, as compared with 36% before the war.

HIGH INTENSITY ELECTRON LINEAR ACCELERATOR

A 25-million-volt electron linear accelerator, which is expected to be considerably more efficient and to have a higher power output than any similar machine yet built, is now under construction by Metropolitan-Vickers and will be installed at A.E.R.E., Harwell.

In this machine, which is of the travelling wave type, electrons are accelerated by the axial component of an electric field set up by the propagation of radio frequency power in a wave-guide of circular cross section. This is the principle which has already been adopted in similar but smaller equipment made by the Company for use as X-ray generators for super voltage therapy. A number of these machines operating at 4 MeV are already in service in hospitals in Britain and overseas.

The 25-MeV equipment will consist of six sections of accelerating wave guide structure arranged in tandem. Each section is approximately 1 metre long and is energized by a 6-MW (peak) Klystron amplifier. The Klystron amplifier may be operated at a pulse length of 2 microseconds and a recurrence rate of up to 750 pulses per second, thus producing a mean power of 9 kW. It will be possible to set the electron pulse lengths at any of several values between 0·2 and 2·0 microseconds ; the pulse recurrence rate can also be varied.

The accelerator is, of course, evacuated to a very low pressure, and for this purpose the equipment from the Company's own range of vacuum pumps and accessories is used.

The construction of machines such as this accelerator involves many problems, not the least of which is the dimensional accuracy required in the accelerating structure. The permissible variations demand a close control of thermal expansion, and therefore it is necessary not only to circulate cooling water around the accelerating structure, but also to maintain the temperature of the cooling water constant within a few degrees.

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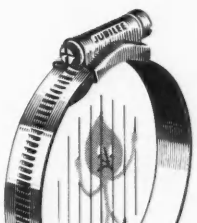

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INTERNATIONAL MACHINE TOOL EXHIBITION 1956

Olympia · London · June 22 — July 6

Exhibition open daily (Sundays excepted) 9.30 a.m. to 6 p.m.
Admission 3/6*d*. Exhibits include machine tools, engineers' small tools, gauges and measuring equipment, testing equipment, presses and power hammers, heat-treatment plant, woodworking machinery.

Organized by The Machine Tool Trades Association, Victoria House, Southampton Row, London, W.C.1.

In operation, the high energy electron beam and the very high level of X-ray radiation produced when this beam is absorbed in any target could present a very serious danger to operating personnel. A system of interlocks is therefore incorporated to switch off the equipment if entry to any of the danger areas is necessary. Similar interlocks are provided for protection against high voltage and also to safeguard the equipment in case of component failure or incorrect operation.

When completed, the machine will be used to generate intense pulses of neutrons, by the interaction of the electron beam with a uranium target, for use in time-of-flight spectroscopy and other applications.

THE BRITISH INDUSTRIES FAIR, 1957

Mr. J. Ivan Yates, Chairman of the Fair Management Committee, in an interview on the subject of next year's much-discussed B.I.F., gave the following information :—

" The 1957 British Industries Fair will be held at Castle Bromwich, Birmingham, from the 6th to the 17th May. All the facilities necessary for staging it on a large scale exist at Castle Bromwich, and the preliminary preparations for doing so in 1957 are now in hand.

Space will be available for exhibitors from the London Section of the Fair ; any British or Commonwealth manufacturers will be eligible and will be welcomed as exhibitors.

The British Industries Fair will be presented as a general or samples Fair for the mutual convenience of buyers and manufacturers, for whom an exhibition of this nature is eminently suitable. The management considers that the British Industries Fair and specialized exhibitions are complementary to one another and each, in its own way, serves British Industry.

Castle Bromwich is easily reached from all parts of the country by air, rail and road ; it has parking for over 5000 cars and coaches and adequate accommodation for trade buyers and exhibitors. Direct air services from the Continent operate to the City's airport at Elmdon, which will be augmented.

The exhibition hall is all on one floor, which is a great advantage. The cost of space will be 6*s*. 6*d*. per square foot, and the all-in cost of participation, e.g., food, sleeping accommodation, standfitting, furniture, electricity and space rental, is under £1 per square foot of space booked.

The policy of open and semi-open stands will be continued, because of the increased display value and low costs of construction. As in the past, contract work will be put out to competitive tender to ensure the lowest charges for all services.

Publicity will aim at keeping overseas and home trade buyers fully informed about new developments, processes and products, so that they will be able to decide in advance what is of interest in their line of business. Direct mailing will be greatly increased, and advertising and posters will be concentrated to allow for a reasonable coverage.

LOWER EGYPT TELEPHONE NETWORK

A far reaching project is announced by the Egyptian Republic Telephone and Telegraph Administration to establish a new communications network in Lower Egypt. The scheme involves the most up-to-date techniques for telephony over coaxial cables, with provision for the future transmission of television programmes.

The total route of more than 400 kilometres in the Delta provides communication between Cairo, Benha, Tanta, Damanhour and Alexandria over a cable containing six coaxial tubes, with an extension from Tanta to Mansoura of a four core coaxial cable. . .

Between Cairo, Bilbeis, Zagazig and Jamailia, a further cable of four tubes will be installed.

Initially, two coaxial tubes will be equipped to provide telephone and broadcast circuits over each route. Amplifier stations will be installed at approximately ten kilometre intervals. Each pair of coaxial tubes, when fully equipped for telephony will provide 960 speech channels. Alternatively, one pair of tubes may be equipped for the transmission of a television programme over each cable route.

Provision is made in the cables for a high quality, two-way music circuit by the inclusion of two screened pairs. In addition, the cable to be installed between Cairo and Alexandria will contain a number of carrier circuits suitable for use as Group to Zone Centre connections.

Thus, the Nile Delta will shortly have in operation by the Administration, the most modern long-distance telecommunication system, the cable and equipment for which is being supplied entirely by Standard Telephones and Cables Limited, who have been entrusted by other leading telephone administrations throughout the world with the provision and installation of similar systems. In this case the Delta network is being installed by S.T.C. in conjunction with Administration engineers.

The order for this network was obtained in the face of severe competition from Continental countries.

BETTER LIGHTING THE FIRST STEP TO INCREASED PRODUCTIVITY

" Bring the Sky Indoors " was the slogan given as the first step towards increased productivity by Mr. J. Gogan, M.I.E.E., chief commercial officer, South of Scotland Electricity Board, when introducing a paper on " Better Lighting for Commercial and Industrial Buildings by Illuminated Ceilings ", at the Electrical Development Association's annual conference of electricity supply sales staff at Caxton Hall, Westminster.

Mr. Gogan said that the future of this country depended on higher productivity and the first step towards this objective was a higher standard of illumination.

This standard of better illumination should start in our schools ; in our technical colleges ; in our universities, for it was in those places that the foundation for increased productivity was laid. Having laid a good foundation they should continue by installing this better lighting in the research laboratories, the drawing offices, the general offices and factories—not forgetting the managing director's office.

Another important factor in better lighting was the welfare of those who work indoors. An even brightness similar to that which was got from the sky would contribute greatly to the well-being of those who worked indoors, and also would contribute to higher productivity.

An architectural feature of this form of lighting was its facility to conceal unsightly beams, pipe work and other surfaces and it added to the economy of new buildings as well as modernising older ones.

CONFERENCE ON HEAT TREATMENT PRACTICE

At this conference, organized by the Metallurgy (General) Division of B.I.S.R.A., to be held at Ashorne Hill, near Leamington Spa, on June 5 and 6, 1956, the Chairman will be Mr. E. W. Colbeck of Hadfields Ltd., and the Vice-Chairman, Mr. W. C. Heselwood of United Steel Companies Ltd.

The first session will be concerned with distortion and cracking problems. Papers will be delivered by Mr. F. D. Waterfall (I.C.I. Ltd.) and Mr. P. E. Clary (Ford Motor Company Ltd.).

Session two, on heating for forging and treatment, will be introduced by a paper from Mr. O. Hirston (Brown-Firth Research Laboratories) on " The Principles of Equipment to Ensure Good Heat Flow in Furnace Charges ". This will be followdd by a paper on " Heat Flow in Large Forgings " by Dr. F. W. Jones, also of Brown-Firth Research Laboratories.

The third and last session is concerned with transformations. Mr. H. Allsop (Brown Bayley Steels Ltd.) will give a paper on " Isothermal Transformation Diagrams ", and Dr. W. Steven (The Mond Nickel Company Ltd.) will conclude with a paper on " Continuous Cooling Transformation Diagrams ".

Application forms and full details of the arrangements can be obtained from the organizer and secretary, Mr. J. R. Powell, of the British Iron and Steel Research Association, 11 Park Lane, London W.1.

BUSINESS NOTES

A.M.T. (B'ham) Ltd., 505 Bristol Road, Bournbrook, Birmingham 29, have been appointed Midland agents for Maiden & Co. Ltd., Hyde, Cheshire, manufacturers of threading machines, and for

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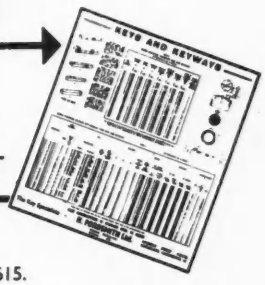

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Manchester Repetition Engineers Ltd., Hyde, Cheshire, manufacturers of M.R.E. centring machines.

Courtburn Positioners Ltd., with works at Kempston Hardwick, Bedford, and sales offices at Goldington Bury, Bedford, has been formed to manufacture a new patented design of general purpose positioner and work handling equipment. Mr. C. V. Ibbett is chairman, and Mr. K. E. Partridge is managing director of the company. Mr. Eric Courtney is sales director.

Wild-Barfield Electric Furnaces Ltd. announce the transfer of all activities of their A.H.F. Induction Heating Division from Cricklewood to Elecfurn Works, Watford-by-Pass, Watford, Herts.

Automotive Engineering Ltd. have recently improved their range of circlips. Sizes have been included covering shaft diameters from $^3/_{32}$ in. upwards and bore diameters from $^7/_{16}$ in. upwards. Metric sizes in the same range are also manufactured.

Each circlip is individually tested before leaving the works to ensure that the circlip is capable of withstanding the most stringent conditions that may be met with in service.

This additional range of small circlips should be of great interest to manufacturers of small electrical appliances.

The low cost, safety and simplicity of locating and fixing these components as compared with other methods which are now widely adopted makes these small circlips a valuable means of lowering production costs.

The Plant Engineering Division of the British Iron and Steel Research Association will hold its 13th Conference in Sheffield on Tuesday and Wednesday, 3rd and 4th, July, 1956, on the theme of Works Transport. The main emphasis will be on road transport methods and demonstrations of various types of vehicles are being arranged. Further particulars and details of the arrangements for the conference may be obtained from the Technical Secretary, Plant Engineering Division, B.I.S.R.A., 140 Battersea Park Road, London, S.W.11.

The A.E.I. Lamp and Lighting Co. Ltd., announce a reduction of up to 12% in the price of their sodium lamps, together with the introduction of a new, and more rugged, outer jacket with an improved performance and a simple, reliable leak detector.

This greatly improved vacuum flask outer is fitted with a smoothly contoured metal cap to prevent damage to the exhaust seal-off pipe which has, in the past, proved vulnerable during transit and handling. Another measure to prevent damage from vibration is a supporting wire frame which has been introduced between the inner and outer walls of the vacuum space. It is on this frame that the metallic "getter", which indicates the presence of a leak, is carried. A leak in the flask causes the "getter" to change colour from grey to white or crumble completely away. The "getter" also serves to create a harder vacuum in the flask by absorbing any oxygen present after the seal-off during the final stages of manufacture.

The extensive range of Mazda, Royal "Ediswan" and Metrovick candle lamps have also been reduced in price by the A.E.I. Lamp and Lighting Company Ltd. The reductions range from approximately 20% to 33% throughout the range.

The Fourth International Conference on Hot Dip Galvanizing will be held in Milan from 11th–13th June, 1956. It will be similar to the previous conferences organized by the Zinc Development Association, 34 Berkeley Square, London, W.1, who are being assisted on this occasion by the newly-formed European General Galvanizers Association.

"Productivity in Hot Dip Galvanizing", a report just published by the Hot Dip Galvanizers Association, is a review on productivity in the American general galvanizing industry, and is based on a study made by the Association's industrial engineer late in 1954. It is the first of a series which the Association will be issuing this year as part of its productivity service for the industry, which was set up some 18 months ago and has so far been financed jointly by a grant from the Board of Trade out of the M.S.A. counterpart funds placed at its disposal, and by the Association.

Mr. Northcott's report describes the study of some twenty American galvanizing plants. Four main factors are thought to account for the very high general level of productivity in the U.S.A. galvanizing industry. These are :—vigorous competition : cost consciousness in all sections of management : constant improvement in operating methods, and the achievement of greater continuity in the flow of work through the galvanizing bath. Ten proposals are made for increasing productivity in the U.K. galvanizing industry.

The body of the report outlines the American approach and the importance attached to plant layout and materials handling, and describes the industrial engineer's part in planning these efficiently and in setting standards of performance for all operations. Human relations within the industry are considered in connection with the progress made in management and education, safety and good housekeeping, and in relations with the trade unions.

The appendices include a detailed description of a profit-sharing plan considered to be in the forefront of such schemes and based on considerations of the self-interest of management and men ; a description of an unusual incentive plan for all sections of management based on the control of costs and their progressive reduction ; and a brief description of a third incentive scheme based on standard times.

The report may be obtained from the Hot Dip Galvanizers Association, 34 Berkeley Square, London, W.1. Price 7*s.* 6*d.*

Steel, Peech and Tozer, of Rotherham, a branch of The United Steel Companies, are spending £180,000 on a new cold rolling mill and associated annealing equipment, which will enable output of narrow steel strip for the strapping, tube and bicycle industries to be stepped up by about 50 per cent.

The new mill will come into production during June and will roll at least 1,000 tons of steel a month into strip up to 9 in. wide. It will supplement the output of the three existing mills in the company's cold rolling department, which are currently producing over 20,000 tons of steel strip annually.

BRITISH STANDARDS

(*Copies of British Standards may be obtained from the British Standards Institution, 2 Park Street, London, W.1.*)

Vertical mild steel welded storage tanks with butt-welded shells for the petroleum industry. Part I : Design and fabrication. B.S. 2654 : 1956 specifies the materials, design and fabrication of vertical cylindrical tanks, with butt-welded shells, for erection above ground. The tanks are of the following types :—

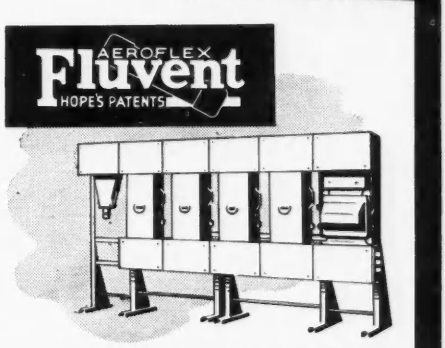
a. Non-pressure fixed roof tanks (all sizes).
b. Pressure fixed roof tanks (up to 128 ft diameter only).
c. Open top tanks (all sizes).

Tanks with floating roofs are excluded. Reference is made to mounting, stairways and handrailings. There are numerous tables and twenty-two illustrations. Price 15*s.*

Screwed studs. Part I : General purpose studs. B.S. 2693 : 1956 gives full information, including limits and tolerances for the threads, for screwed studs intended for general use. The principle adopted is that of mating an oversize stud with a standard tapped hole and the amount of oversize and the thread tolerances specified are those considered suitable for most purposes.

The very wide range of applications for which studs are used makes it impossible to provide a single grade of stud which, while being economic to manufacture, will meet the most arduous as well as the more ordinary requirements. Discussions on a higher grade of stud are now in progress, but in order to make available the general information relating to overall dimensions, length of thread, etc., it was decided to issue this, together with limits and tolerances for the threads of the general purpose grade as Part One of the standard. Details are given for studs with UNF, UNC, B.S.F. and B.S.W. threads in diameters up to 1½ in. and for studs with No. 2 and No. 4 B.A. screw threads. Price 3*s.* 6*d.*

Dimensions of condenser rubbing leathers for cotton waste and woollen carding engines. B.S. 2716 : 1956 has been issued as part of the programme of standards for accessories, which is being developed by the Textile Machinery Industry Standards Committee.



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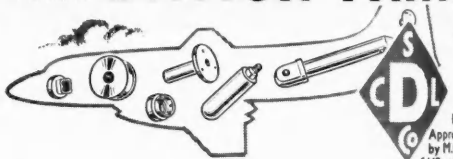

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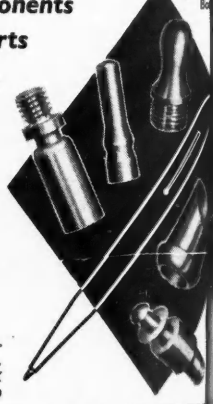

The DIAMOND SCREW & COTTER Co. Ltd.
Cherrywood Road, Bordesley Green, B'ham 9. *'Phone VICtoria 2748 PBX*
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The aim which the Textile Machinery Industry Standards Committee held in view when preparing the standard was to establish by agreement among machine makers, condenser rubbing leather makers and users, standard dimensions for single rubber tape condensers and single stripper condensers used in the cotton waste and woollen trades.

B.S. 2716 provides a range of three widths of condenser rubbing leathers for carding engines 60 in., 66 in. and 72 in. wide for the production of cotton waste yarns and woollen yarns. Two lengths of condenser rubbing leathers are specified, for rubbing rollers with 12 in. and 14 in. nominal centres respectively.

The rubbing leathers are suitable for both single rubber tape condensers and single stripper condensers used in the cotton waste spinning and woollen spinning trades. Price 2*s*.

CONTRACTS

The Loewy Engineering Co. Ltd. has secured an order from The Patent Shaft & Axletree Co. Ltd. of Wednesbury, South Staffs, for a complete Blooming & Slabbing Mill and a Plate Mill worth over £1,500,000, to be delivered by mid-1958.

The Fraser & Chalmers Engineering Works of The General Electric Co. Ltd. has received an order through its Australian associate, British General Electric Co. (Pty.) Ltd., for an ore handling and preparation plant for the Australian Iron & Steel Co. Ltd.

This plant, which is for installation at Port Kembla Steelworks, New South Wales, will handle iron ore ranging in size from 4 in. cube to dust, at the rate of 800 tons per hour. Sinter conveying equipment is also included.

The plant comprises three main sections. The first deals with raw ore, which, arriving by rail, is dumped into bunkers whence it is conveyed to an ore screening station. The larger products from screening are conveyed to bunkers for feeding the blast furnaces and open hearth furnaces, while the smaller fraction is conveyed to fourteen storage bunkers, each of 1,000 tons capacity.

The second section deals with coke, limestone and flue dust which, after screening, are stored in further bunkers. These materials, with the fine ore, are the components for sinter making.

The third section of the plant comprises conveyors to take the materials from the bunkers, and deliver the mixture to the sinter machines.

The complete plant includes the 44 conveyors, 8 Gyrex screens, bunkers and all ancillary equipment. It is being designed by the Erith Works, which will also supply the mechanical equipment, while the structural steelwork will be manufactured in Australia.

Davy and United Engineering Company Limited of Sheffield are to build Rolling Mill and Railway Wheel Tyre and Axle Plant worth about £7 million for the new integrated iron and steel works which the Government of India is to establish at Durgapur in West Bengal. This contract follows the announcement of the agreement now reached between the Government of India and the Indian Steel Works Construction Company—ISCON—the British Consortium Company formed specially by Davy-United and other metallurgical engineering firms to undertake the construction of the whole plant at a total cost of some £85 million.

This order represents the biggest single enterprise ever undertaken by Davy-United. It includes a 42 in. Blooming Mill, a 32 in. Intermediate Mill, a 24 in. Medium Section Mill, and Continuous Billet Mill and Merchant Mills, together with a 6,000 ton Wheel Forging Press, a 2,000 ton Dishing Press, Wheel and Tyre Roughing and Finishing Mills, and a host of auxiliary equipment. To spread the work and thereby assist delivery, Brightside Foundry & Engineering Company Limited of Sheffield, are collaborating with Davy-United and will build the 32 in. Mill.

Delivery of the plant will begin in about two to two-and-a-half year's time. The contract will occupy about one-third of Davy-United's capacity over a three year period, leaving at least twice that capacity for essential work for the home steel industry and for other exports on which Davy-United are already engaged and expect further commitments.

In addition to rolling mill and wheel production machinery, Davy-United have also undertaken to act as main contractors for all buildings, cranes, furnaces, soaking pits, electrical equipment, foundry and central maintenance shops. All this work, totalling another £18 million, will be shared out amongst other companies in the ISCON group and elsewhere, but Davy-United will be responsible for co-ordinating engineering and manufacture and for progressing the whole scheme.

The underlying conception of this ISCON project, whereby the Indian Government has been able to order the entire plant as a "package deal"—meaning a complete steel works built and handed over ready to operate, is an example of the imaginative way in which thirteen British companies engaged in iron and steelworks engineering are tackling the export of heavy capital plant by practical collaborative action.

Rolling mill auxiliary equipment to the value of nearly £1¼ million has been ordered from **Davy-United** by **John Summers & Sons Ltd.**, for an extensive modification scheme which that Company are carrying out at their Shotton Works, near Chester.

Davy-United are to build a considerable amount of Slabbing Mill equipment including ingot cars, ingot transfer car and make-up table at the ingot receiving table, scarfer entry table, scarfer entry and delivery side guards, trailing carriage and pinch rolls, a 1,350 ton hydraulic hot Slab Shear with auxiliaries, tables from the shear to the slab piler, piling equipment and slab transfer car. For the following Hot Strip Mill the new equipment required is also extensive. It includes pile receiving equipment, pile storage tables and depiling gear with pusher ; furnace entry and delivery tables with entry skids, pushers and bumpers ; much new roller table gear and side-guards, chutes, loopers and guides as well as other auxiliaries. In all, over 4,000 tons of new machinery will be supplied.

The contract forms an essential part of a large-scale development programme now being carried out by John Summers & Sons to raise the capacity of the Shotton Works to the point where it can deliver annually some 1,250,000 tons of finished products.

Electrical equipment worth over £250,000 has been ordered by **Samuel Fox & Co. Ltd.** from **Metropolitan-Vickers Electrical Co. Ltd.**, Trafford Park, Manchester. It is for two hot reversing rolling mills, which are to be commissioned in 1957 at Stocksbridge Works, Sheffield ; they will receive blooms of all types of alloy steel from a 36 in. blooming mill, one mill rolling billets down to 2 in. square, and the other producing rounds from 12 in. to 2¾ in. diameter. The combined capacity will be 10,000 tons a week.

The new mills, the electrical equipment of which will be identical, will be driven by 4000-hp (r.m.s.) 60/150-rpm d.c. motors capable of taking peak loads up to 12,000 hp. Each main motor is to be supplied from a motor generator set consisting of two 1600-kW generators driven by a 4800-hp (r.m.s.) synchronous motor. The use of synchronous motors instead of the more usual slipring induction motors and flywheels will enable the mill drives to operate at a higher efficiency as well as improving the power factor. The control system, incorporating amplidyne regulators, provides fast response and quick reversal with safe and reliable operation.

Instructions have been given to **British Insulated Callender's Construction Company** by **Sir Alexander Gibb and Partners** to supply and supervise the installation of an electrical network for the new weapons range at Maralinga, in the heart of the South Australian desert.

The work in Australia will be carried out in collaboration with British Insulated Callender's Cables (Australia) Pty. Ltd.

The General Electric Co. Ltd. has received an order from the New Merton Board Mills Ltd., London, for the supply of a 6,000 kW, 3,000 rpm pass-out turbo-alternator and associated condensing plant.

Designed to supply power for an extension of the mill for the manufacture of container and chip board, this set will be installed in a new power house, and will be supplied with steam at 315 psig, 630°F. It is required to pass a maximum of 133,000 lb of steam per hour to process at 35 psig. To meet the demands which may be made on the machine by different types of products manufactured at the mill, the pass-out governor will be capable of hand adjustment from 15 to 45 psig throughout the whole range of extraction demand.

The enclosed alternator, direct-coupled to the turbine, will have a continuous maximum rating of 6000 kW at 3·3 kW, 0·8 p.f.

Consultants for the contract are Messrs. J. D. Crozier & Partners Ltd. of London, W.C.1.

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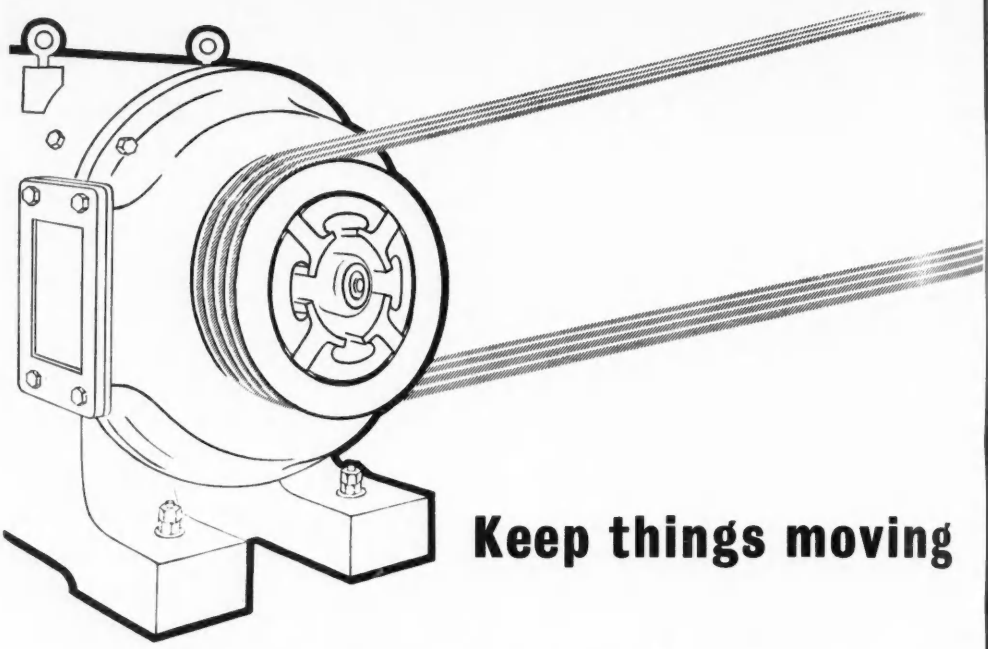

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The inclusive fee for the course of study is £71 1*s*. In certain cases where a student is not sponsored by an employer, the University may consider applications for the remission of this fee and, where essential, for the grant of a maintenance allowance during the period of attendance.

Further particulars and application forms may be obtained from the Registrar, The University, Birmingham 15. Applicants are advised to apply before 1st August but applications received after this date may be considered if places are available.

SITUATIONS VACANT

INDUSTRIAL CONTROL
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The Industrial Control Department (Servo Section) of Metropolitan-Vickers Electrical Co., Ltd., is expanding and has vacancies for **Graduate Electrical Engineers** with experience of magnetic and electronic amplifiers. A good technical knowledge of the theory of closed loop control systems is necessary and some background on conventional (open loop) industrial control gear practice would be an advantage.

The work involves design and application of closed loop control for a wide variety of industrial motor drives, e.g., for Steelworks, Mine Winders, Paper-making Machinery and Machine Tools, etc.

The posts are permanent and pensionable.

Apply for application form, quoting reference " Y.4.", to :
Personnel Manager,
Metropolitan-Vickers Electrical Co., Ltd.,
Trafford Park, Manchester 17.

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DRAUGHTSMEN

Men who have completed their National Service, for work in connection with the above, and also for the general development of prototypes.

Applications, giving full details, should be sent to the above address.

MATHEMATICIAN required for a post in connection with the analysis of process control systems and servo-mechanisms.

Applicants should preferably have a degree in Electrical Engineering or Physics, and have had experience on such work. A knowledge of servo theory is of advantage. Successful applicant will be required to use analogue and digital computation for his work. The post is permanent and pensionable.

Apply for Application Form, quoting reference " K.5.", to :
Personnel Manager,
Metropolitan-Vickers Electrical Co., Ltd.,
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For marine research work. A minimum standard of H.N.C. is required, and sea-going experience with Board of Trade Certificate will be a distinct advantage.

The above requirements offer a splendid opportunity to the right type of men, and good salaries will be paid in accordance with experience, ability and training.

The Barrow district is an extremely pleasant one in which to reside, offering the close proximity of sea, countryside and the Lake District. In suitable circumstances, housing accommodation may be available if required by successful applicants, and a contributory pension scheme is in operation.

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Applications giving full details, should be sent to the Labour Manager at the above address.

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BOOKS RECEIVED

Strength and Elasticity of Materials (Vol. IV) : By W. H. Brooks, Ph.D.(Eng.), B.Sc.(Eng.), London. 464 pp., 349 illustrations. Publishers : Macdonald & Co. (Publishers) Ltd., 16 Maddox Street, London, W.1. Price : 35/-.

This book is supplementary and complementary to preceding volumes of Solutions I, II, and III, and contains complete and many alternative solutions to all questions set between 1941 and 1952 inclusive in the B.Sc.(Eng.) Part II General External Examination papers in Strength and Elasticity of Materials, Papers I and II, of London University. As in the former volumes, the solutions are grouped in sections, each dealing with a particular type of problem, for the benefit of readers who may wish to concentrate on one type of problem at a time.

Teachers will no doubt find this book time-saving and helpful, inasmuch as students may be referred to these solutions for supplementary study and exemplification, following lectures covering varying parts of the syllabus. In this connection, it has been assumed by the author that students have been or are attending courses of lectures in this subject, or have prosecuted private reading, so as to enable them to be familiar with the establishment of the formula used.

Manganese Steel. 138 pp., 87 illustrations. Published for Hadfields Limited, Sheffield, by Oliver and Boyd, Tweeddale Court, Edinburgh, and 39A Welbeck Street, London, W.1. Price : 18/-.

It is more than 75 years ago since Robert Abbott Hadfield embarked on the study of irons with other elements and started the series of experiments which culminated, in 1882, in the discovery of manganese steel. Since then, because of its remarkable properties, manganese steel has continued to attract serious attention from many investigators. Nevertheless, despite the fact that many publications have appeared, this is the first time that the full story of this material has been written.

Containing the contributions of many individuals who have helped to extend and improve knowledge of this unique alloy, this interesting book covers the accumulated experience of more than fifty years of research, development, and manufacturing knowledge. Indeed, the contributors to this book, who include a wide cross-section of the staff of the Hadfield Organization, have successfully provided an authoritative and up-to-date account of present knowledge on manganese steel, together with details of its historical background.

The book, which is well illustrated by line drawings and photographs, contains a historical introduction, and chapters on general characteristics ; manufacture and processing ; properties ; heat treatment ; transformational characteristics and metallography ; work-hardening, abrasion, and wear resistance ; influence of temperature on properties ; modifications in composition ; non-magnetic steel for electrical applications ; welding, hard-surfacing, brazing, and oxygen cutting ; and industrial applications. In addition, a useful bibliography and index are provided.

LATEST INDUSTRIAL LITERATURE

1. Electrical Control Gear. A well-produced 40-page catalogue gives details of electrical control gear from the recently formed British subsidiary of a prominent American switchgear manufacturer. Clearly illustrated, the catalogue describes in detail a wide range of control gear, stated to be more flexible in use and easier to install and maintain than similar equipment previously available in Great Britain. The items shown include multi-pole relays, motor starters, push-button units, limit and pressure switches, timing relays, thermal overload relays, and voltage testers, all of which are now in production and immediately available.

2. Precision Pulse Oscilloscope. Details are given in a series of leaflets of an interesting new precision pulse oscilloscope, designed primarily for making quantitative measurements of the characteristic features of pulsed or transient wave-forms. The synchronizing, time-base, and deflection circuits are d.c.-coupled, to enable the instrument to make precise measurements of time on non-recurrent or randomly spaced phenomena. Of particular interest is the high beam-current cathode-ray tube, with high-efficiency blue screen for photographic purposes, giving a bright, sharp trace under full daylight conditions.

3. Charting and Graphing System. Described and illustrated in a series of pamphlets, a novel charting and graphing system features a number of interesting innovations, designed to extend its usefulness in a wide range of applications. The panels used in the system are constructed of laminated bakelite and can be used either horizontally or vertically; furthermore, they can be extended, as required, and are so constructed that signals, etc., cannot be dislodged accidentally. A full range of accessories is available, including letters, numerals, flags, arrow indicators, title indicators, anchored flow-lines, and self-return flow lines, made of specially selected elasticated graph cord.

4. Reinforced Grinding Wheels. In a neatly produced and illustrated 6-page brochure, details are given of a range of reinforced grinding wheels of different grades and sizes. These wheels provide greater strength and safety, inasmuch as they are reinforced with layers of strong fabric material. In addition, moulded into the hub side is a strong safety web, which prevents them from flying apart, even should accidental breakage occur during use. Furthermore, they cut rapidly and cleanly without spalling or hardening, as a result of the use of a special sharp and durable abrasive, a special resinoid bond, and an exclusive file-like cutting surface.

5. Screwing and Cutting-off Machines. A well-produced and illustrated 8-page brochure details a range of screwing machines for tubes, bends, nipples, bolts, rods, and fittings, and a similar range of tube cutting-off machines and combined screwing and cutting-off machines, The range includes works-type and rotary-head production machines. semi-production and general-purpose machines, and bench-type general-purpose machines. Direct electrically driven, belt-driven, petrol-engine-driven, and manually operated models are available.

6. Electronic Air Cleaners. Details are contained in a 4-page illustrated pamphlet of electronic air cleaners with a number of important features, including a built-in washing system which incorporates nozzles and manifold and which is supplied as an integral part of the equipment. By merely opening a valve, located outside the duct, the entire filter is washed, including ionizers, collecting cells, and insulators. In addition, the ionizing-collecting cells are specially constructed for corrosion resistance and ease of handling, while the plates are separated by an exclusive method which assures even spacing and provides a corona shield to conserve current and to increase efficiency. Finally, the equipment includes a bank of mechanical, waterproof, dry-type filters built into the clean-air side of the duct.

A supplementary pamphlet covers oil-mist precipitators specifically designed to meet the requirements of industry for the elimination of coolant oil mist and smoke emanating from high-speed cutting, grinding, and machining operations.

7. Swivel Connections. Compared with flexible hose, the range of hydraulic swivel couplings and connections described and illustrated in a 4-page brochure has a number of important advantages, among which may be mentioned the fact that these swivels are lighter in weight, have a longer life, offer greater flexibility, and withstand a higher temperature range. Furthermore, despite the fact that flexible hose and these hydraulic swivels can be designed for equally high pressures, flexibility is seriously reduced, in the case of hose, as pressure is increased.

These swivels are available as swivel couplings, comprising a pin and banjo fitting with A.G.S. connection outlets for fixing to pipes, or as swivel connections comprising two links of the required length with swivel couplings at their junction and at each end.

8. Heavy-Duty Parting Tool. A pamphlet describes and illustrates a new heavy-duty parting tool with a Stellite blade tip, combining excellent cutting qualities with the strength of a solid blade tip. The tool does not suffer from flutter in action and will operate efficiently, even when red-hot. Furthermore, it has a wide speed range, can be reground on normal wheels, and will give many times the life of a normal tipped tool. A complete range of sizes is available.

9. Precision Micro-Switches. Designed to combine precision, durability, and reliability in many industrial applications, a wide range of micro-switches is described and illustrated in an 8-page brochure. The snap-action switch movement, in which all moving parts have free hinges, consists of a moving contact arm, a leaf spring, and an operating trigger or rocker assembled to a base moulding, complete with a setting device. The travel of each switch is set individually to 0·016 in., $\pm$ 0·0005 in., thus enabling each switch to trip at the same point of depression of the plunger or actuator on repeated operations. Furthermore, depression of the plunger in no way affects contact pressure and, as the switch has a snap action, it can be operated slowly, the danger of the moving contact being held in a midway position being completely eliminated. Another feature of these switches—not usually found in micro-switches—is that contact pressure is equal in both positions, i.e., whether the plunger is at rest or depressed. The rating of these switches, the contacts of which are of fine silver, is 5A at 250 V a.c., or 5A at 12 to 29 V d.c.

10. Anti-Vibration Nut. A 4-page pamphlet describes and illustrates an anti-vibration nut with numerous advantages. Thus, for instance, it resists vibration indefinitely, yet can be used over and over again without loss of efficiency ; it eliminates thread fatigue by equal support of both thread flanks ; it is self-adjusting, and maintains full thread engagement on rough or out-of-square surfaces ; it is unaffected by oil ; it seals threads against corrosion ; it can be reasonably overtightened without damage to the efficiency of the bolt or nut ; and it is specially made for high-temperature use, maintaining full efficiency at temperatures up to 750°C. The nut consists of a stack of conical metal elastic discs firmly assembled in a hollow nut body, and it is to this laminated construction that it owes its pronounced elasticity.

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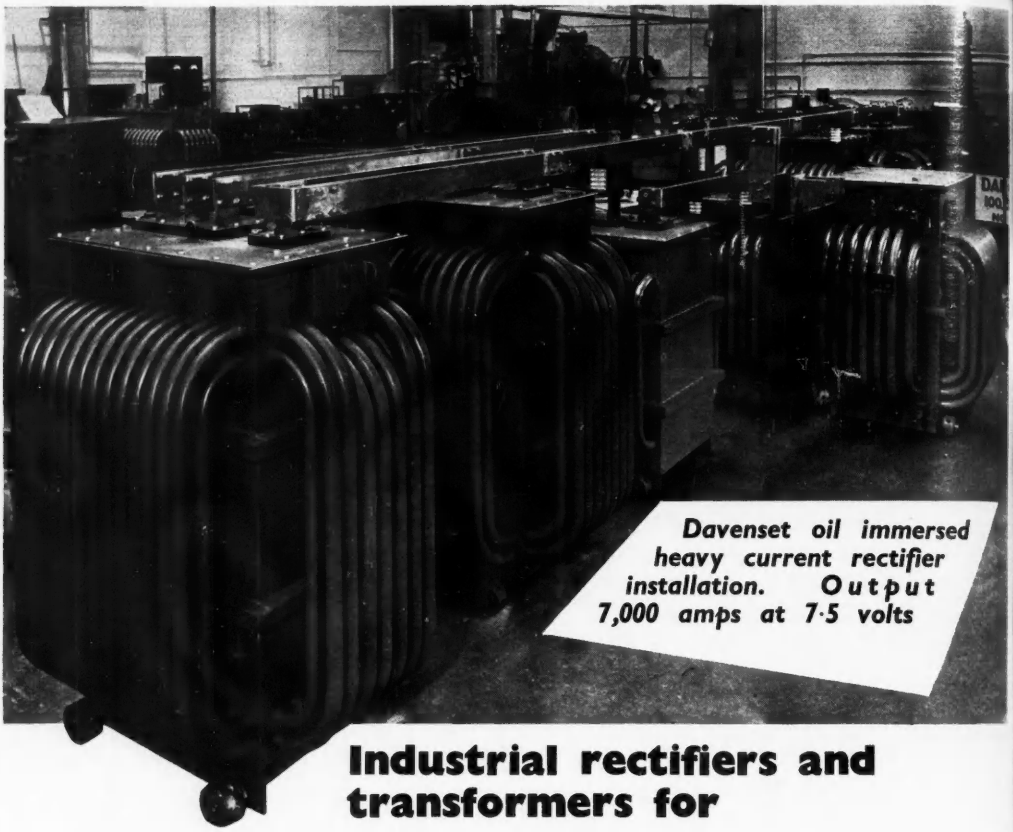

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